92-06526/

SUMMARY - FINAL REPORT

MIRAMICHI RIVER

ENVIRONMENTAL ASSESSMENT COMMITTEE

1989-1992

TABLE OF CONTENTS

	Page #
DEDICATION	iii
EXECUTIVE SUMMARY	1
1. General statement	1
2. Major conclusions and recommendations	3
CHAPTER 1. HISTORICAL BACKGROUND	8
CHAPTER 2. THE NATURE OF THE PROBLEMS	10
1. The people's perception	10
2. The technical assessment perspective	15
CHAPTER 3. WATER ANALYSIS	17
1. Introduction	17
2. Metals	19
(a) Previous studies	19
(i) Naturally-occurring levels	19
(ii) Levels in the lower reaches	22
(iii) Levels in the Tomogonops River System	23
(b) MREAC Study	24
(i) Group I Sites	25
(ii) Group IIa Sites	26
(iii) Group IIb Sites	27
(iv) Group III Sites	28
(v) Group IV Sites	29
3. Acidity (pH) and other factors	30
4. Organic and suspended materials	32
(a) Estuarine sites	32
(b) Large wastewater treatment plants	36
(c) Small sewage treatment plants	37
(d) Solid waste dump sites	38
5. MREAC Bacteriological Survey	39
6. Bulk Petroleum Storage Facilities	40
7. Water levels	41

	Page #
CHAPTER 4. BIOTA ANALYSIS	42
1. Tissue analysis	42
(a) Heavy metals	42
(b) Chlorinated dibenzodioxins (dioxins) and dibenzofurans (furans)	42
(c) Pesticides	43
(d) Chlorophenalic compounds	43
(e) PAH^s	43
(f) PCB^s	44
(g) EOX	44
2. Benthic faunal communities	45
(a) Introduction	45
(b) MREAC Study	46
CHAPTER 5. SEDIMENT ANALYSIS	48
CHAPTER 6. DREDGING	50
CHAPTER 7. THE ATLANTIC SALMON	52
1. Anecdotal	52
2. Historical	53
3. Present	54
CHAPTER 8. SHELLFISH HARVESTING	55
CHAPTER 9. GOVERNMENT PROTOCOL AND LOGISTIC PROBLEMS	57
CHAPTER 10. PROPOSED GUIDELINES FOR MREAC	61
MREAC MEMBERSHIP	63
ACKNOWLEDGEMENTS	64
GLOSSARY OF TERMS	66
MAPS	69-74
FIGURES	75-110
TABLES	111-157

DEDICATION

We dedicate this report to Mrs. Joyce Allan. Her presence has been sorely missed by all of us who have come to know her through this committee.

She represents not only what this committee was envisioned of becoming, but the direction and difference such an undertaking can bring about. A change in attitude and an awareness of the relationship between the quality of life and our environment has grown on the Miramichi. People of different interests and backgrounds talking to each other, looking for answers and solutions. As a member, her enthusiasm and energy brought this committee to deal with and educate itself in many varied issues, and while she was its Chairperson, her dedication and integrity continued to earn respect for both herself and to strengthen the committee's sense of purpose.

We all share in the delight of having known Joyce and we all share a deep sense of loss and of sorrow at her untimely death.

EXECUTIVE SUMMARY

1. General Statement on the Health of The Miramichi River System

When it was formed in January, 1989, the Miramichi River Environmental Assessment Committee accepted the task of assessing the health of the Miramichi River due to widespread public concern, an apparent lack of knowledge, and an apparent failure to fix things that went wrong. The size of the challenge and the amount of data generated were much greater than anticipated, hence the delay in producing this report. Even now, with a two-year study completed, it is almost impossible to make a short concise statement on the "health of the river" at the beginning of this Summary Report. However, the Committee believes it is important to make this overall statement and encourages you to read this Summary Report in full. If you are interested in having more detail than that provided in this extended summary, the full, Final Report will be available later.

Following the general statement below, is a list of the major conclusions and recommendations that emerge from the MREAC study. The key questions are:

(a) **Are the levels of contaminants enough to make the water unsuitable for drinking or swimming?**

(b) **Are the levels of contaminants enough to make the water unsuitable as a habitat for fish and shellfish?**

(c) **Are the levels of contaminants enough to make the fish and shellfish unsuitable for eating.**

The answers to these key questions cannot be unequivocal and we would answer them thus:

(a) **After routine treatment in most areas, the water is safe to drink; and, waters are safe for swimming at many locations but not at all;**

(b) **In most, though not all, parts of the River System, the water is suitable as a habitat for fish and shellfish <u>at present</u>;**

(c) **<u>In general</u>, most contaminants are not enough to make any commercial species of fish unsuitable for eating although elevated levels of mercury in striped bass make it unsuitable for consumption by children and pregnant women. Contamination of shellfish with faecal coliform bacteria has caused closures of large areas in the Bay and complete closure of the Upper and Lower Estuary.**

As is clear, the answers are not unequivocal and a clear "yes" or "no" is not possible. However, except for localized areas discussed in this report, the river is in reasonable health considering the level of human development which has taken place on its shores. The fact that it is in reasonably good health is more a matter of good luck, through its ability to absorb abuses, than to good management. We are stressing the Miramichi River and its biota and pushing it toward its limit. The ability it has to absorb abuses is

severely limited as is its buffering capacity. It is imperative that we recognize these limitations since there are now only three options for the future:

(1) **Continue uncontrolled growth and development and depend on good luck to protect the river;**

(2) **Stop all further growth in the Miramichi River watershed;**

(3) **Develop a sense of commitment to the river and convert that into an organized plan for phased improvement and future protection.**

We have taken our River near the edge but have not pushed her over yet! We are fortunate to have time. Some other rivers have gone beyond the edge and repair is impossible or will be measured in decades. Even the worst problems of the Miramichi can be repaired in 10-20 years; the lesser ones in less. Now is a turning point.

As must be obvious, option (1) above will inevitably result in the gradual death of what has been a fine river. As is also obvious, option (2) will cause many problems, beyond environmental ones, for the people of the Miramichi.

The Committee believes that the only option is (3)! The recommendations in this report are all directed toward that commitment to the future of the River and its people. We found many things wrong within government, industry, and municipal/residential controls. These problems were created by people; the Committee has confidence that they can be solved by people, as long as they work together.

The following conclusions and recommendations are grouped by chapter topic. Thus, the conclusions and recommendations relating to Chapter 3: Water Analysis come before those relating to Chapter 4: Biota Analysis, and so on. This should make it easier for the reader to find the information in the text on which the conclusions, and hence the recommendations, are based.

2. Major conclusions and recommendations

Chapter 3: Water Analysis (metals and acidity)

The following conclusions (o) and recommendations are not listed in order of priority but follow the order in which they appear in the following summary.

- o Although there are sporadic, high elevations of metal contaminants in the upper reaches of the river, the probable, and assumed, short duration of these does not present a serious problem.

- o The base-line concentrations of certain metals in the upper reaches are well above the Canadian Freshwater quality Guidelines. This reflects the geological formations of the area rather than human activity.

- o Because of the Heath Steele mining operation in the Tomogonops River System, levels of copper and zinc remain sufficiently high to kill all fish close to and below the mine. Although levels of these metals are close to the toxic threshold, fish can live in the Tomogonops River close to its confluence with the Northwest Miramichi.

- o Present levels of copper and zinc in the Northwest Miramichi after the confluence with the Tomogonops are much lower than earlier levels and do not pose any problems. These levels could rise and cause problems if there is an accident or equipment malfunction at the Heath Steele Mine with spills of toxic waste entering the Tomogonops River.

- o Levels of aluminum, though not considered to be toxic at present, are sufficiently high to cause concern throughout the watershed if the pH of the water drops below 6.5. (Such a drop could result from the effect of continued acid precipitation.)

- o Average acidity values for the Napan River and the Black River are already at, or close to pH = 6.5.

- o The levels of metals in the estuarine waters are of no concern due to the buffering effect of salt water which causes precipitation and binding of metals.

- o The combined effect of low pH and increased metal toxicity are considered to be much more important than pH alone with respect to fish mortality.

Based on the above conclusions, we recommend:

1. **Extensive investigation of the metal binding properties of humic and fulvic acid, particularly with respect to copper and zinc.**

2. **Careful, regular monitoring of the pH of selected tributaries to determine the effect of acid precipitation.**

3. **National and provincial efforts towards abatement of acid precipitation are strongly endorsed; these efforts should be increased.**

Chapter 3: Water Analysis (organics and suspended materials)

- Neither suspended solids nor total dissolved solids appear to be a problem within the freshwater system at this time although the potential for it to become a problem is present.

- There does not appear to be any problem related to organic chemicals in solution at the freshwater sites sampled.

- Concentrations of Biological Oxygen Demand material (BOD_5), Suspended Solids (SS), Total Phosphorus (TP), and Total Kjeldahl Nitrogen (TKN) are considered to be somewhat less than acceptable, because several wastewater treatment plants, including the town of Newcastle, discharge effluent into the Miramichi River System well in excess of the Provincial standard limits.

Based on the above conclusions, we recommend:

1. **All wastewater treatment plants be required to meet the Provincial standard limits established.**

2. **All households currently dumping raw sewage into the Miramichi River System be required to use septic tanks or other approved means of waste disposal.**

3. **The jurisdiction for all sewage and wastewater control be vested in one government Department, to facilitate both monitoring and control because the present split of responsibilities has resulted in problems.**

Chapter 4: Biota Analysis

- Although there do not appear to be significant chemical contamination problems in the biota sampled in the Estuary, a few samples analysed had elevated levels of mercury.

- White suckers and lobster tomalley show levels of dioxin higher than in other species. After reviewing concentrations of all contaminants and consumption patterns, Health and Welfare Canada determined that a health advisory warning was not required.

- Levels of chlorophenolic compounds in the biota analysed were low, overall, and usually near or below the detection level.

Based on the above conclusions, we recommend:

1. **More work on mercury analyses of white suckers and striped bass.**

2. **As the pulp mill bleach plant of MPPI makes planned equipment changes to eliminate dioxin discharge, white suckers and lobsters should be monitored for expected decreases in dioxin levels.**

3. **Benthic invertebrates and water should be sampled and analysed from carefully selected sites to monitor the effects of point source discharges directly into the Miramichi River System.**

Chapter 5. Sediment Analysis

- Contaminants in sediments below the Chatham (Centennial) Bridge, in the lower Miramichi Estuary, present no risk to the Environment.

- Contaminants in sediments above the Chatham (Centennial) Bridge in the upper Miramichi Estuary, and for some distance up the Northwest Miramichi River, are above the Washington Marine Sediment Guideline, in some cases more than double, and may be adversely affecting aquatic biota.

Based on the above conclusions, we recommend:

That the sediment in the upper Miramichi Estuary be sampled on a finer grid to outline the polluted areas for a more definite and better defined risk assessment.

Chapter 6: Dredging

- There is a lack of data on the effects of dredging on aquatic life and clear-cut conclusions about the biological effects may never be reached.

Based on the above conclusion, we recommend:

1. **Any dredging be limited and undertaken only after a cost/benefit analysis.**

2. **If dredging is economically required, it is recommended that it be done in the upper Miramichi Estuary only after very careful consideration of the effects of stirring toxic sediment into the water column.**

3. **If future dredging be considered, careful monitoring of the effects be done at the same time as well as later.**

4. **Biological monitoring (using fish and invertebrates) be established at a few, carefully selected sites.**

Chapter 7: The Atlantic Salmon

- There are environmental factors, particularly the combination of metals and low pH as indicated elsewhere, which pose potential threats to the Atlantic salmon, especially during the egg and embryo stages. These factors, however, pale by comparison with past and present over-exploitation of this valuable species.

Based on the above conclusion, we recommend:

1. **Metal contamination of the Northwest Miramichi River should continue to be reduced.**

2. **Efforts must be maintained to reduce acid rain caused by long range transport of pollutants.**

3. **Custody of the Atlantic salmon, in fresh and estuarine waters, be given to the Provincial Department of Natural Resources.**

4. **The first priority in managing this valuable stock, must be conservation.**

Chapter 8: Shellfish Harvesting

o Increasing areas of prime molluscan shellfish habitat are being closed to shellfish harvesting because of contamination by untreated sewage.

Based on the above conclusion, we recommend:

1. **Communities and private home owners be required to use appropriate sewage treatment facilities which conform to Provincial regulations.**

2. **The Provincial Departments of Health and Community Services, Environment, Agriculture, and Municipal Affairs and the Federal Departments of Fisheries and Oceans and Environment Canada all work together to identify one department with responsibility for both monitoring and regulating shellfish areas for harvesting.**

Chapter 9: Government Protocol and Logistic Problems

o An inordinate amount of time and effort is wasted, because of overlapping responsibilities, by government departments. Because of poor communication and coordination between and within different government departments, problems are not always dealt with as expeditiously as they should be, or, if at all! The lack of accessibility to the general public, due to some departments being located at long distances from the Miramichi area, contributes to the above problem.

Based on the above conclusions, and, because of specific problems discussed in this Chapter Pages 57-60 inclusive, we recommend:

1. **There should be only one, locally-accessible agency responsible for dealing with pollution in streams, rivers, and lakes. This agency must be held accountable for its actions and must report back to the individual or organisation to inform of what action, if any, was taken.**

2. **DFO needs to be much more intimately involved with the concerns of the Miramichi.**

3. Because of the many competing forces buffeting DFO, much of the science gets hidden. if DFO is to remain the primary organization providing lab analysis, then its science branch needs to gain independence from the rest of the organization. The mandate of this branch needs to be clearly established. This mandate should establish that a clear priority is given to the local aquatic ecosystems and the communities that inhabit them and it should also establish the exclusion of political considerations. Research and management control are not good bedmates!

4. DFO has inadequate field work taking place on the Miramichi to assess competently the status of the many different stocks of Atlantic salmon that run into the river. It is recommended that DFO direct more of its efforts towards scientific research on river systems and less effort on management and enforcement in the freshwater areas of these systems. As recommended elsewhere, Provincial agencies seem to be in a better position to carry out these functions of management and enforcement.

5. The Miramichi community should have well-publicized and local access to DFO and it should have its branch located on the river.

6. Sampling and testing procedures for faecal coliforms need to be standardized among government departments. There should be only one department responsible for the regulation of sewage systems regardless of the source.

7. There needs to be a periodic survey of the whole river so that the local population can check to find the probable degree of safety from pollution for swimming in any given area.

8. National labs should be available to analyse biota and sediment samples to the appropriate level of accuracy.

9. Municipalities should not be allowed to expand beyond their capacity to treat the sewage that is generated. There are at least four government agencies involved with the regulation of sewage. The problem continues to worsen. There should only be one agency and it should be accountable for results.

10. There has to be more attention paid to the problem of illegal dumping of sewage by those responsible for hauling septic tank waste.

11. There should be ONE advertised contact point, available to the general public, which deals specifically with pollution and environmental concerns relating to the Miramichi River System, its Estuary and its Bay. The responses and actions of government to any concerns reported, should be constantly reported back to an involved public. MREAC would be willing to play a role in this.

CHAPTER 1

HISTORICAL BACKGROUND

For over 300 years, the Miramichi River and its Estuary have supported human settlements in diverse ways providing water and food, recreation and a way of life for human settlements along its banks. During this time, there has been much progress. But, progress means different things to different people. Invariably, however, progress means change. As our lifestyles change for the better in terms of personal comfort, prosperity, health care, and more time for recreation, this can be at the expense of our environment which may be changing for the worse.

For about 50,000 New Brunswickers, the environment is the Miramichi River System and progress through the years has resulted from more efficient utilisation of various resources and exploitation of others.

For many individuals, the time had come to question the value of such progress in relation to the perceived deterioration of their environment. Clearly, this did not translate into a "back-to-nature" movement with abandonment of cars, television sets, telephones, electricity, medicines, and the plethora of other modern conveniences; more, it was a heightened awareness that a balance must exist and that although the benefits of modern life are not only desirable but even necessary, the health of the environment is equally desirable and, perhaps, also necessary.

In 1988, Miramichi Pulp and Paper, Inc. completed an expansion at their mill situated south of Newcastle. There was significant public concern about the potential impact that such an expansion would have on the Miramichi with questions raised as to the lack of an Environmental Impact Assessment. The company (M.P.P.I.) acknowledged they had made a mistake and New Brunswick's Department of Municipal Affairs and Environment requested that a Committee on Public Information and Public Concerns be formed particularly with respect to any future expansion projects of Miramichi Pulp and Paper Inc. This Committee had a membership of 21 members with Mr. Joseph O'Neill, Manager of Woodlands Operations for Miramichi Pulp and Paper Inc., as its Chairman. The membership included concerned citizens, representatives of both Provincial and Federal Government Departments, and company representatives. The Committee met for the first time on January 16, 1989 and, at its fourth meeting on February 21, 1989, it made several recommendations including:

1. **A 2-year study be made of the Miramichi River System to assess its health;**
2. **That the Committee stay in place to monitor the study;**
3. **That the Committee define the terms of reference for the study;**
4. **That the cost of the study be shared by Miramichi industries, municipalities, and both federal and provincial government agencies.**

The estimated cost of the study was $100,000.

The Miramichi River Environmental Assessment Committee (MREAC) evolved from the Miramichi Pulp and paper Inc. Committee on Public Information and Public Concerns becoming a more formal and completely independent body. MREAC became operational on April 18, 1989. Included in the terms of reference was an assessment of the environmental quality of the Miramichi watershed by way of a two-year study which was designed to identify and quantify both point, and non-point, sources of pollution and to determine the effect of contaminants on water quality, on aquatic life, and on the river sediments. The study area extended from the watersheds of the headwaters of the various tributaries to the barrier islands separating the Inner Miramichi Bay from the Outer Miramichi Bay. The total area is about 14,300 square kilometres of which 14,000 represents the total drainage basin area and 300 the estuarine area.

The two-year study was supported by contributions from local industry, municipalities and special interest groups as well as by provincial and federal governments which provided additional technical and administrative support.

CHAPTER 2

THE NATURE OF THE PROBLEMS

1. The people's perception

> **This section ("The people's perception") represents the perception, rightly or wrongly as will be seen in later sections, of some of the people of the Miramichi. This is not to be interpreted as the findings of the M.R.E.A.C. but more the reason for the study, in order to find the real answers.**

The people of the Miramichi remember the benefits of a clean river. During more recent times, however, there has been a gradual erosion in the quality of the river system which has increased markedly the perception that the river is not being looked after and that pollution is out of control.

Many of the older generation, now in their 70s, 80s, and 90s, can remember back to a time when the river itself was the focal point of life on the Miramichi. They still have vivid memories: of the three passenger boats that plied the length of the Miramichi daily; of the thriving bass fishery under the ice; of skating under the old covered bridge; of running to help open the span when a boat blew its whistle; of church picnics and swimming in Bushville (in front of what is now the Golf Club); of swimming at Vye's Beach (between Newcastle and the Mill); and of the plentiful supply of freshly caught salmon. They also remember vividly the annual spring drive of logs down the river.

The not-so-old generation, in their 40s, 50s, and 60s can remember the many nets set separately for salmon, shad, and later for gaspereau which at times seemed to fill the river with their whirlpools of flashing silver and gold. They can remember first the waiting, and then the joy, of eating the first-run salmon, bass, and shad. Many happy gatherings were organized around these important events. They can also remember the roar and the grind of the ice as it finally relinquished its hold on the river.

But what is happening? Why are the swimming spots now closed: first Bushville; then Vye's Beach; then the Enclosure? What has happened to the commercial fisheries: to the bass fishery; then to the salmon; then to the shad; and then to even the gaspereau, with bans on netting?

It seems that even such drastic measures as closing down the commercial fishery for salmon has done but little to rescue this declining population. Set nets and drift nets in the Bay were prohibited, only to be replaced by gill nets at Eel Ground and Red Bank reserves. Still, the once plentiful salmon continues to decline causing even the recreational fishery to be closed for large fish. At the same time, trout stocks have been drastically reduced and are also still in decline.

In the vernacular of the Miramichi, the concerns would sound somewhat

like the following expressions, repeated over and over again in endless variation.

-- sometins wrong, there was an oily taste on the little grilse I caught the othr day. Don't suppose it was that Domtar did it do yas?

-- ya know, the fish I brung in last week was real soft. Sometin's damm well wrong alright.

-- I was up t' Moose Landin the other week and ya know I waded right down thru the middle of er and the water barely up to my knees. Cripes, a few years ago you could hardly get thru ther with a pair of chest waders. And they say clearcutting don't make no difference.

-- Ya know, there are hardly any large fish any more. This time of year we useta catch all large fish. Now all we get are these little net-marked grilse. Holy dyin, a fish would have to have radar or sometin to get thru those Indian nets.

-- There was eight fish landed in this pool today an' holy jumpin, every blasted one of em was net-marked. Yeah, I caught six fish this year; every one marked.

-- Jees, if I was landin that fish, I wouldn't let er go. Ally'r doin is saving er for the Indians. Slip er into the boot, lad.

-- Ya might as well stay home as talk to those fellows in Fisheries. Yeah, those fellows in Ottawa have er some screwed up.

-- It's a shame the way that gravel pit on the Oxbow is fillin in the river. They should never have let em put er there in the first place.

-- Yeah, the whole river is getting filled in. Did ya ever notice how the whole area under the Red Bank Bridge is fillin in?

-- Ya remember that area in front of Wilfred Ward's? There's no water there now like there useta be.

-- The fall run is not in too bad a shape, it's the spring and summer runs that are hurtin. There's nuthin left.

-- Damm govement! There's not even enough field staff left to know anything. They should fire all those airey fairey types in Ottawa and give us some workers here on the river.

-- Did ya ev'r notice that there are a lot more female grilse than there useta be? There was maybe 2 in 10 females. Now, I calate over half of 'em are female.

-- There's no fish in the South Sevogle any more.

In the Bay area in the late 70's

-- Every year this slime gets worse. We useta be able to fish way on into July before we saw any slime.

-- Did ya ever notice there are a lot of scarred fish these days? Must be them seals.

-- Did ya hear? Them govement fisheries fellas went all over the place yesterday and only got four small grilse and one large salmon. There's not goin to be any fish. There's not even enough to breed.

-- The hatchery is only puttin out a fraction of what they useta. They'll be closin that next if we're not careful.

-- Ya know she's not producin. Over 20% of the fish caught at Millbank were hatchery fish last year.

-- We need to start shootin them merganzers agin.

-- Did ya hear they're shuttin down the Newfies from catchin our fish? I suppose now they will give em all to the Indians.

-- Yeah, sure is bad!

-- Yeah, sure enuf is. Darn!

-- It's a darned shame. Yeah, real sad.

Present generations can remember the changes to the oyster and clam fishery: the gradual decline in numbers of shellfish at favourite spots; and the relentless march of the closure line down the estuary due to bacterial contamination from sewage. What follows are the thoughts and perceptions of commercial fishermen from Miramichi Bay.

-- Fishing used to be called a poor man's job but now some are making a decent living. The technology and fishing gear is getting better but, with the increased cost of operation, there is a need to make more money.

-- We all hear stories passed down from our forefathers of crabs and herring that were so plentiful that they were hauled onto the gardens and fields as fertilizer.

-- People still remember the villages formed of shanties on the ice, the flat lands, the dunes, and Portage Island. I still hear stories of the large smelt runs. My father recalls the happy times, the bad times, the snow storms, and the late icing of the Bay. Now, there are only a few smelt in

these areas.

-- There was also the lobster fishing; the bad storms and the loss of fishing gear. The lobster fishery had its ups and downs with the catches in the mid'50's and '60's being very poor. In the late '70's, the catches went up and have now stabilized at a good level, especially from the mid '80's.

There are several reasons for this including decreased cod stocks, control of the number of licence holders, control of the number of traps per fisherman, an escape mechanism on every trap, and a tight control on poaching.

-- The salmon drift-netting is vividly remembered. The happy landings and the disasters where many fishermen lost their lives at sea.

The salmon drifting rights have been taken away from the commercial fishermen. This was the fisherman's survival fishery in the late 50's and 60's.

-- Herring, which were so plentiful, were greatly diminished in the '50's and '60's. They are starting to make a comeback, now.

-- Oysters were very plentiful and quahaugs were just developing into a commercial crop when there was a virus attack which almost wiped out both species in the Bay. Although the oysters have come back to some extent, they have not regained their former abundance.

-- With the announcement of the closure line at Oyster river to Point au Quart in 1971 fishermen became scared of talking about pollution for fear that DFO would close the whole Bay. They are only too aware of the effects of pollution in this area.

-- There is room for hope although the Maritime Fisherman's Union warns that: "The future of the commercial fishery lies in the hands of the polluters."

-- The fishermen in the Bay have many concerns with respect to pollution including concerns about the lack of control of sewage, increased dumping of toxic wastes, the poor methods used to dredge, and dumping of garbage and oil from boats and ships. They note that in some cases there has not been an actual increase in the concentration of pollutants but, with increased production, the net effect is the overall quality of the river is still going down.

There are other changes. Small, mixed farms in the valleys, and family sawmills are being exchanged for pulp mills and mining for metals. Small settlements have become villages. Villages have become towns. And with these increases, more and more wastes are being dumped into the river.

Older pollution problems of sawdust, bark and sewage have become newer pollution problems of pulp fines, bark fines, creosote, heavy metals, acid spills, chlorinated organics, more sewage, oil spills, foam, insecticides, and.....and.....and..... . To the average Miramichier, the list seems endless and ever increasing.

The close friend the Miramichi, the giver of so much, was sustaining one assault after another. Miramichiers were only too aware of the blackening of the river bottom and shore with bark and fibre from the two pulp mills, of the devastation of the Northwest Miramichi by mine discharges, of acid and oil spills, of the build-up of DDT, of ugly foam floating up and down with the tides, of inadequate sewage treatment, of government departments that ignored the reports of abuses by its own inspection staff in spite of the call-ahead policies of inspection departments, of mills that did not maintain their primary lift pumps (choosing instead to discharge directly to the river), of the Domtar debacle, of alarming levels of metals in the river, of the callous disregard for small streams by woods contractors, of the disappearance of dangerous chemicals into the river at night, of mysterious fish kills explained as: "due to natural causes!", of tainted fish, of stinking home sewage pipes discharging directly to the river, of inadequate inspection staff, of slime and scum on the water and the itch after swimming, of government departments that were never the right ones to deal with the problem, and aware of people who betrayed, and betrayed again their close friend, the Miramichi River.

2. The technical assessment perspective

It was clear that there were real limitations as to what could, and could not, be assessed given the two-year duration of the study and a finite budget. The original Committee on Public Information and Public Concern had already identified several areas for study, based largely on the people's perception of what was causing the problems. MREAC, in an extensive review of what information was already available, delineated the two-year study taking the expressed concerns into account and based on the following four, key considerations:

1. **The various users of the river;**
   (e.g. fisheries, towns, pulp mills, mining.)

2. **The nature of their use;**
   (e.g. depletion of fish stocks, waste disposal.)

3. **The effect of this use on different parts of the river;**
   (e.g. in the headwaters, in different tributaries, in the main branches, and in the estuary.)

4. **What to use as measures of health.**
   (e.g. water chemistry, sediment quality, contaminants in fish and other organisms, numbers and types of bottom-dwelling insects and other living organisms.)

What became manifestly clear, was that a wide range of regulatory bodies was involved in decisions regarding the use of the river and in enforcing their own regulations. What was disconcerting was the total absence of coordination or cooperation among these agencies including the Provincial Departments of Environment, Health and Community Services, Natural Resources and Energy and the Federal Departments of Environment, Fisheries and Oceans, and Health and Welfare. The jurisdiction of some agencies overlapped with others but despite this, there was no evidence of <u>any</u> coordination nor of maximizing the environmental protection of the Miramichi River system.

With all of the above considerations in mind, the two-year study was planned to include:

1. **Investigation of all point sources of waste disposal;**
   (This was to determine where these sources were and to determine the nature of wastes being dumped into the river. e.g. industrial discharges, sewage discharges, municipal and industrial garbage dumps, bulk petroleum storage plants, sawmills, trailer park and schools discharges.)

2. **Determination of water chemistry at different locations throughout the river system;**
   (This was planned especially for the freshwater part of the system with analyses from the headwaters to the estuary. Substances to be tested for and measured included metals, certain organic contaminants, dissolved organic carbon, level of acidification (pH), and suspended solids.)

3. **Counts of bacteria at selected sites;**
   (Sites were chosen to determine, if possible, the effect of contamination from sewage and or industrial waste.)

4. **Examination and analysis of sediment in the estuary;**
   (Due to the incredibly complex nature of water analysis in estuarine conditions, where chemical concentrations fluctuate so much due to mixing with salt water, it was felt that a better assessment of contaminants likely to be harmful could be made from analysis of the sediment.)

5. **Chemical analysis of various fish and shellfish tissues;**
   (Much is known about the accumulation of various chemical contaminants by different organisms; through analysis of samples chosen, it would be possible to determine what chemicals had been accumulated and whether the levels were harmful either to the fish themselves or to human consumers.)

6. **Counts of insects and other animals in different parts of the river system;**
   (Such counts both of numbers of individuals as well as diversity of different species present, can give valuable information as to the "health" of the river where the samples are collected.)

In addition to the collection of new information, as indicated above, the Committee was also interested in how the river had changed over the past 10, 20, or 30 years. To this end, where possible, previous data was gathered. The ultimate goal of the study was to bring to the attention of the public and government what, if anything, was wrong with the health of the Miramichi River System with some expectation that any problems identified would be "fixed".

CHAPTER 3

WATER ANALYSIS

1. Introduction

It must be remembered that any conclusion is based on the assumption that the chemical analysis data are correct. It must also be remembered that these data can, and not infrequently do, contain errors.

Pure water (H_2O) does not exist in nature and is actually toxic to living organisms: "It is the presence of many trace substances that makes water essential to all forms of life."

Within the Miramichi River System, various substances occur naturally in the water. Even in the absence of any human intervention, the concentrations of these substances can fluctuate greatly due only to natural, environmental changes such as water flow and temperature.

It can be argued, perhaps, that all parts of the Miramichi watershed have been influenced to some extent or other by human activity; whether by logging operations, forestry practices, wood processing plants, mining, or by human habitation. Some of these activities, over the years, have clearly had a greater impact on water quality than others. However, by comparing water from the upper sections of various tributaries, where we would expect it to be least contaminated if at all, with water from the lower sections and from the estuary it should be possible to quantify the accumulative effect of human activity on the system prior to its discharge into the sea.

The concentration levels of metals, and other substances, in water are usually expressed as weight (of metal) per volume (of water). The units used in this study are usually either milligrams per litre (mg/L) or micrograms per litre (μg/L) which approximate, respectively, to parts per million (ppm) and parts per billion (ppb).

When such data are compiled, for ease of comparison with other sets, they are often expressed either as "average" (= "mean") concentrations or as "median" concentrations. The use of average concentrations, however, is valid only if the range of concentrations does not exceed the range in which organisms can live.

The same caution must be taken in interpreting median concentrations which simply provide information as to the concentration below which 50% of all samples are recorded. The critical information for any data set, accordingly, is the range of concentrations recorded, with particular reference to the highest concentrations. The following example illustrates these terms.

If ten samples are analysed for a metal and show the following results:

Sample	1.	2 mg/L of metal
"	2.	1 mg/L " "
"	3.	2 mg/L " "
"	4.	7 mg/L " "
"	5.	2 mg/L " "
"	6.	3 mg/L " "
"	7.	21 mg/L " "
"	8.	2 mg/L " "
"	9.	6 mg/L " "
"	10.	4 mg/L " "

The **average** concentration is the total sum of all values (50 mg/L) divided by the number of samples (10) and would be 5 mg/L of the metal.

The **median** concentration is the concentration at which at least half of the values are equal to or below and in this case would be 2 mg/L. (Samples 1, 2, 3, 5, and 8 are all at 2 μg/L or below it.)

The **range** of concentrations in this data set is 1 mg/L (lowest) to 21 mg/L (highest).

If the **lethal** concentration of this metal (the concentration that kills the organism in question such as brook trout or Atlantic salmon) is 15 mg/L, then the average of 5 mg/L or the median of 2 mg/L are misleading figures because all the organisms could have died when the concentration was at its maximum level of 21 mg/L. It is <u>essential</u>, accordingly, to provide maximum figures before making use of average or median figures. We could use temperature as another illustrative example:

> **A comfortable average temperature for us to live in is about 20°C. If the extremes are only a few degrees on either side, we can still be more-or-less comfortable. However, if the low extremes are -200°C and the upper extremes are +300°C, not only would it be most uncomfortable but we probably would not survive!**

2. Metals

(a) Previous studies

(i) Naturally-occuring levels

Although there are several instances of highly elevated levels of metals at stations in the upper reaches of the Main Southwest, it is likely that such maximum peaks were of short duration. These high peaks are possibly associated with a temporary increase in run-off, after a warm dry spell, with oxidised metal salts from exposed bed rock being washed into the river.

Water samples of the upper reaches of the Miramichi River system were collected and analysed from several sites, some 30 years ago. Among these sites were the upper reaches of the Northwest Miramichi, where DFO collected and analysed samples, and the upper reaches of the Main Southwest Miramichi where Environment Canada had sampling stations (Map 1). In particular, the concentrations of copper (Cu) and zinc (Zn) were measured as these were known to be toxic to most aquatic organisms including Atlantic salmon.

Present-day guidelines for "safe" concentrations of various metals and other substances in water have been established for aquatic organisms and are published as the Canadian Freshwater Quality Guidelines (C.F.Q.G.). These concentrations are derived as being levels at which there is no toxicity nor harm to any aquatic organism. For example, the C.F.Q.G. for copper is given as 2 µg/L (in 'soft' water). For young Atlantic salmon (fry or parr), the lethal level of copper in the water has been established at 48 µg/L. Concentrations higher than this will kill fish within one to two days (see Table I).

As can be seen in Fig. 1 (i), the monthly average for copper concentrations in the upper reaches of the Northwest Miramichi (above any possible contamination from the mine on the Tomogonops River) ranged from being undetectable during March, April, August, and September, to 4 µg/L during July and October. These average figures were obtained from weekly samples collected throughout 1963 and the maximum concentration of copper recorded during the year was from one sample collected on Nov. 1, 1963 which had a level of 8 µg/L of copper.

It should be noted that the levels found, which exceed the C.F.Q.G. for 3 months, are not due to any known human activity.

These levels reflect the presence of copper in the bedrock of the drainage basin and over which water flows before entering the river.

Analysis for zinc from the same site is shown in Fig. 1 (ii). As can be

seen, the monthly averages for zinc concentrations range from 1 µg/L in Sept., 1963 to 10 µg/L in Jan., 1963. The maximum recorded zinc level was 20 µg/L on Jan. 11, 1963. The "safe" level for zinc in the C.F.Q.G. is 30 µg/L and so, for this metal, all samples were well below this safe level.

Similar ranges were recorded from weekly sampling at this site until 1972. For ease of comparison, the annual averages (adjusted to the nearest whole number) for 1962 to 1972 are shown in Fig. 2(i) for copper and Fig. 2 (ii) for zinc along with monthly averages for copper and zinc for 1972 (Fig. 2iii and iv).

Baseline levels of copper and zinc concentrations were also recorded from samples taken from the Sevogle River before it joins the Northwest Miramichi and the average monthly concentrations for 1970 and 1972 are shown in Fig. 3 along with the average annual concentrations from 1966 to 1972.
Both of the above sites (upper reaches of the Northwest Miramichi at Miner's Bridge and the Sevogle before it joins the Northwest Miramichi), as well as a number of other sites from the upper reaches of the Main Southwest, were sampled by Environment Canada over the period 1961 to 1977 and analysed for several substances. Data for this period were published in 1979 and Fig. 4 (i-vi) shows graphically the average and median levels of copper (Cu), zinc (Zn), cadmium (Cd), mercury (Hg), iron (Fe), and lead (Pb) from the seven sites identified on Map 1. The figures also depict the maximum levels recorded and Table II shows the period sampled for each site as well as the number of samples analysed for each of the metals indicated.

Although the median concentration for both copper and zinc are at, or below, the C.F.Q.G., the average concentrations are all above the guidelines for copper as are three of the average levels for zinc. Furthermore, the maximum levels recorded for copper were all of concern except that for the upper reaches of the Northwest Miramichi which showed less than 20 µg/L. Levels of 180 µg/L at Bloomfield Ridge, and of about 70 µg/L both above and below Burnthill Brook on the Main Southwest, with similar maximum values of 70 µg/L on the Cains and Sevogle Rivers, are all higher than the lethal level for juvenile Atlantic salmon (48 µg/L). Such levels could have caused mortalities if they had remained that high for more than a day or two.

Maximum levels recorded for zinc are all above the C.F.Q.G. (at 30 µg/L) but only two exceed the lethal limit of 600 µg/L. One of these, over 1,000 µg/L, was a sample from just above Burnthill Brook; the other, almost 900 µg/L, was a sample from just below Burnthill Brook and both from the Main Southwest Miramichi. As for the maximum copper levels, if these high concentration levels of zinc had persisted for more than a day or two, mortalities could have resulted.

Although cadmium (Cd) shows all median and average values at well above the C.F.Q.G. of 0.2 µg/L, none of the maximum values reached the lethal concentration for fish species. Levels as low as 1 µg/L, however, have been shown to interfere with brook trout reproduction, if present over an extended period, and this level is considered to have chronic (long-term) toxicity. As the median values (i.e. at least half of all samples) at all sites show levels at about 1 µg/L and, with the exception of the Northwest Miramichi, have

maximum values extending well beyond (from twice to ten times) the chronic concentration level, reductions in the brook trout population could well have occurred.

Mercury (Hg) averages were close to the C.F.Q.G. of 0.2 µg/L and the maximum concentrations did not extend beyond 1 µg/L, less than half the recorded lethal levels for this metal.

With the exception of one high spike at the station just below Burnthill Brook, iron (Fe) did not appear to pose a contamination problem.

Lead showed average levels above the C.F.Q.G. at all stations with one average value just over the lethal limit and a very high maximum concentration of over 2000 µg/L. If this average level had persisted for more than four days, extensive mortalities would have resulted.

Whether the elevated concentrations, recorded and noted above, had any deleterious effects or caused any mortalities is not known. It is well worth noting, however, that many of the waters of the Miramichi River System are rich in humic acid and that humic acid binds metals such as cadmium, copper, mercury, lead and zinc rendering the metals less toxic. The extent to which this happens in the Miramichi is not known. <u>This is an area that needs extensive investigation</u>.

As is clear from these base-line concentrations, the geological formations in this part of the Province are rich in certain metal ores. Consequently, the naturally-occurring waters reflect the presence of these metals, often in concentrations that exceed the 'safe' levels recommended in the Canadian Guidelines.

(ii) Levels in the lower reaches

The only metal of any real concern in the lower reaches is copper, especially as this metal can act additively with zinc. In the combined state, these two metals cause mortalities at lower concentrations than each, independently, would cause. However, as indicated for the upper reaches, the water here, is also rich in humic acid which would combine with both copper and zinc and thus reduce the toxicity of both.

Stations sampled in the lower reaches of the Northwest Miramichi and the Main Southwest are shown in Map 2. Extensive sampling was carried out on a daily basis through the 1960s and up to 1972 at Curventon and at Wayerton Bridge on the Northwest branch by D.F.O. Because metals often act <u>together</u> as toxic substances, it is important to look at levels of <u>all</u> metals in each water sample. This is particularly true of copper and zinc combinations. <u>At summer temperatures (about 15°C)</u>: Copper concentrations of 48 µg/L are lethal to young Atlantic salmon in the absence of zinc; Zinc concentrations of 600 µg/L are lethal to young Atlantic salmon in the absence of copper; <u>Half</u> of the lethal copper concentration (24 µg/L) plus <u>half</u> of the lethal zinc concentration (300 µg/L), **if they are together at the same time**, will still kill young Atlantic salmon. These findings led to the development of "toxic units" for copper and zinc which took the concentrations of both metals into account when analysing water samples.

The monthly <u>averages</u> of toxic units, based on copper and zinc concentrations considered together, for the years 1960 to 1972 are shown in Table III for samples taken at Curventon. The combined lethal toxic level is exceeded on a number of occasions but, fortunately, when the temperature is low (i.e. from October to May). Temperatures of about 5°C increase the resistance of young Atlantic salmon to these toxic metals by as much as four times. For example, fish exposed to the lethal concentration of zinc (600 µg/L) would die within two days at 15-17°C but could survive for about eight days at 5°C. The data in Table III, however, does represent <u>averages</u> which indicate that both lower <u>and</u> <u>higher</u> toxic units were present.

Data from the 17-year monitoring survey by Environment Canada for stations in the lower reaches of the Miramichi River System indicate that, with few exceptions, the concentrations for all six metals are more-or-less similar to concentrations found in the upper reaches.

Copper concentrations at all sites are slightly elevated over levels from the upper reaches with all maximum concentrations well above the lethal level. One site, on the Bartibog River, showed a high cadmium level, but this is still well below the lethal level. One site, on the Renous River, showed a high lead level that approached, but did not exceed, the lethal level.

(iii) Levels in the Tomogonops River System

Due to a mining operation associated with the Tomogonops River System, levels of copper and zinc have been high enough to kill all Atlantic salmon and other fish in parts of this System.

Because of the Heath Steele mining operation close to the Little South Tomogonops River (Map 3), and the resulting increases in copper and zinc concentrations throughout the Northwest Miramichi River into which the tomogonops flows, there has been extensive monitoring within the Tomogonops River System as well as in the Northwest Miramichi. Data collected by DFO, in 1972 from samples taken from the Little South Tomogonops River downstream from the portal has been used in the construction of Fig. 5.

The levels of both copper and zinc are high and above the lethal limits, in almost every sample even when considered alone. Combining them would give high pollution scores in every case and expected mortality of any fish that remained there.

(b) MREAC study

During the present, two-year study, 45 different sites were variously sampled for water analysis, for **bottom-dwelling insects and other aquatic organisms**, and for **sediment analysis**. The sites are shown, by number, on Map 4 and Table IV describes each site. Water samples were collected from sites 1-26 and 40-45 in 1989 and from sites 1-24 and 26-39 in 1990. These sites have been grouped together as follows:

Group I contains sites numbered 1, 2, 10, 11, 15, 22, 25, and 26 which are upstream "clean" sites with no obvious focal source of human contamination.

Group IIa contains sites numbered 3, 4, 5, 12, 13, 14, 16, 17, 18, 23, 24, 27, 28, and 29 which are all downstream sites on the main Southwest Miramichi River System.

Group IIb contains sites numbered 8, 9, 30, and 31 which are downstream or contaminated sites on the Northwest Miramichi River.

Group III contains sites numbered 19, 20, and 21 which are on rivers that flow directly into Miramichi Bay on the south shore.

Group IV contains sites numbered 6, 7, 32-35, and 36-39 which are subject to tidal influences in the upper estuary.

Group V contains sites numbered 40-45 which are either in the lower estuary (41, 42, and 43) or in the Bay itself (40, 44, and 45).

(i) Group I Sites

Analyses by MREAC indicate no apparent problems for sites in this group with the possible exception of Aluminum. Levels of aluminum in some samples exceed the current Canadian Freshwater Quality Guidelines of 5 μg/L (with a pH less than 6.5, Calcium less than 4.0 mg/L, and Dissolved Organic Carbon (DOC) less than 2.0 mg/L) and 100 μg/L (with a pH greater than 6.5, Calcium more than 4.0 mg/L and DOC more than 2.0 mg/L). However, factors such as the speciation of aluminum and the presence of humic and fulvic acid reduce the toxicity of aluminum to aquatic biota. Because of lack of data, the risk of aluminum in the Miramichi watershed cannot be estimated at the present time and it is assumed to be lower than risks posed by copper, zinc, cadmium, and lead. It must be recognized, non-the-less, that the long-term effects of acid rain will substantially increase the risk of this metal becoming toxic to Atlantic salmon.

As can be seen from the copper concentrations (Fig. 6, i-viii), only a few samples exceed the C.F.Q.G. and none comes close to the lethal toxic level.

Zinc concentrations (Fig. 7, i-viii), with only one exception, are all below the C.F.Q.G. and, even taken in combination with the copper concentrations, do not come close to the lethal toxic level.

Lead concentrations (Fig. 8, i-viii), in a number of samples are above the C.F.Q.G. of 1 μg/L but none of the samples shows concentrations anywhere near the lethal toxic level.

Aluminum concentrations (Fig. 9, i-viii), show great fluctuations even within one station. When the acidity of the water is close to neutral or slightly on the alkali side (i.e. pH of 6.5 to 8) then even high levels of aluminum are harmless. Furthermore, like copper and certain other metals, aluminum forms ligands with humic acid and this will also lower the potential toxicity of this metal to fish. Although the effect of aluminum on Atlantic salmon is not known, either at high or low pH values, relatively low concentrations of aluminum (75 μg/L) can cause mortalities (in juvenile rainbow trout) if the pH is less than 6.5. As can be seen, all sites show many monthly samples with more than 75 μg/L. The pH in most water samples is 6.5 to 7.3 but it frequently goes below 6.5 especially at the time of snowmelt and the spring runoff (ref.?). As the geological composition over most of the Miramichi watershed does not provide much buffering capacity for acid precipitation, should the waters show reductions below 6.5 for any extended periods, toxicity from aluminum could become a real problem.

Iron concentrations (Fig. 10 i-viii) are mostly below the C.F.Q.G. of 0.3

mg/L with only a few samples containing higher amounts. The only two samples to approach the lethal threshold of 1.0 mg/L was one taken from the site at Juniper Station in July, 1990 and one taken from the site on the Sevogle River in July, 1989.

(ii) Group IIa Sites

Although there are occasional elevated maximum values of some metals, that potentially could be of concern, these were probably of short duration and probably were not lethal. The levels of aluminum, however, could be of concern if the waters became more acid as indicated for Group 1 sites.

Copper levels (Fig. 11, i-xiv) are slightly higher for several of these sites than in the Group I sites with some samples showing concentrations up to 10 μg/L. No samples approached the lethal level of 48 μg/L and this metal does not appear to pose any problem in these sites on the Main Southwest Miramichi River System.

Zinc concentrations (Fig. 12, i-xiv) were below the C.F.Q.G. for all samples in 11 of the 14 sites. The only three sites showing some samples with more than the recommended safe limit were on the Main Southwest Miramichi itself at Boiestown, Doaktown and Quarryville. none of these even approached the lethal level of 600 μg/L and even taken together with the copper levels from the same sites, there does not appear to be a problem here.

Lead concentrations (Fig. 13, i-xiv) are mostly low and well below the recommended "safe" levels. There are a few samples with elevated concentrations, the highest reading from a May, 1990 sample from Blackville of 38 μg/L. Even this, however, is well below the lethal level of 58 μg/L and probably does not pose a problem as all other samples from this site, except one, had concentrations of less than 1 μg/L, 8 of the 12 monthly samples being less than 0.1 μg/L.

Aluminum concentrations (Fig. 14, i-xiv) showed the same tendency as from sites in the upper reaches, to fluctuate greatly even from the same site. At Blackville, for example, concentrations ranged from about 40 μg/L to over 1,000 μg/L. All samples from all sites had concentrations higher than the safe recommended concentration in the C.F.Q.G. of 5 μg/L in water with a pH of less than 6.5. Over 80% of these concentrations were greater than the lethal level for juvenile rainbow trout of 75 μg/L in water with a pH of less than 6.5. Repeating the comment made for the upper reaches, should the water become uniformly more acid, then levels of aluminum could be of significant concern. Levels as high as 1,000 μg/L at Blackville, in July and September, 1989, should already be of some concern.

Iron concentrations at most sites (Fig. 15) are clearly of no concern being below the safe concentration recommended by C.F.Q.G. at 0.3 mg/L. However, the July, 1989 concentration at Blackville, at about 3.0 mg/L; that

for October, 1989 at the same site, at about 1.0 mg/L; and similar concentrations in July, 1989 and in both July and August, 1990 in the Barnaby River; are at or above the lethal level determined for trout and other species of fresh water fishes. If these elevated levels persisted, in the absence of any natural ameliorating effects, there would be cause for some concern at these two sites.

(iii) Group IIb Sites

The Tomogonops River was still heavily polluted in 1990 with lethal concentrations of copper and zinc combined. An additional study of the Tomogonops River System showed that juvenile Atlantic salmon died within 24 hours if kept in water at two sites within this System. The same caution, with respect to aluminum, is made here as for Group I sites.

Copper concentrations (Fig. 16, i-iv) at Wayerton Bridge (i) on the Northwest Miramichi and in the Tomogonops River (iv) would be expected to be elevated above the baseline levels due to the operation of the Heath Steele mine in the Tomogonops River System which flows into the Northwest Miramichi. This is still the case for the Tomogonops River, based on the four samples analysed. However, the dilution from the Portage River and from the Northwest Miramichi itself brings down the concentration levels in water sampled from Wayerton Bridge (i) compared to those found in the Tomogonops. All samples from the Tomogonops showed concentrations above the C.F.Q.G. of 2 μg/L and several samples from Wayerton Bridge also showed elevated concentrations. None, however, was at the lethal level from the Northwest Miramichi at Wayerton Bridge. The Tomogonops River showed one sample (May, 1990) at the lethal level and the other three still well above the C.F.Q.G. which will be discussed below in relation to their joint action with zinc.

Zinc concentrations (Fig. 17, i-iv) although above the C.F.Q.G., in most samples at Wayerton Bridge (i) are not high enough to be of any concern even if taken jointly with copper concentrations. The same cannot be said, however, for the Tomogonops River where the May zinc concentration, taken jointly with the May copper concentration, gives a lethal toxic combination. The June combined concentrations are close to being toxic with July and August not far behind. There appears to be little cause for concern either in the Little Southwest Miramichi (ii) or at Miner's Bridge (iii) which is in the upper reaches of the Northwest Miramichi and before it is joined by the Tomogonops.

Lead concentrations (Fig. 18, i-iv) at these sites, although showing some samples with levels higher than the C.F.Q.G., do not come close to the lethal level and probably are not of concern based on these data.

Aluminum shows elevated concentrations (Fig. 19, i-iv) at all sites and the same comments, with respect to pH, apply here as in IIa.

Iron concentrations (Fig. 20, i-iv) are low for the most part but reach

2.0 mg/L in two samples: one in January from Wayerton Bridge (i); and one in February from Lyttleton on the Little Southwest Miramichi (ii).

In a separate study of the Tomogonops River System, in which yearling Atlantic salmon were kept at four sites (Map 5), all fish died at site P2 (Little South Tomogonops at the Gauging Station) and site P3 (South Tomogonops at Mine Access Road). Fish held at site P1 (Little South Tomogonops at the Dam) and site P4 (Mouth of the Tomogonops) suffered no mortalities in 4 days. Water from all sites was collected and analysed on two separate days in June, 1990 for various metals.

The analyses of water from each site are shown in Fig. 21 with the concentrations of each metal on both days. As can be seen, the lethal levels of both copper (48 µg/L) and zinc (600 µg/L) are far exceeded at Site P2 (over 200 µg/L of copper and over 4,400 µg/L of zinc). The high concentration of either one of these two metals could easily have accounted for the mortalities observed at Site P2. Copper and zinc levels at Site P3, however, are below the lethal concentrations considered separately but constitute lethal toxicity if combined. In addition, it is interesting that the pH of both Sites P2 and P3 are much lower than Sites P1 and P4 (Fig. 22) which could have rendered the aluminum concentrations toxic at these sites. It is not likely that other apparent differences would have accounted for the mortalities. The high levels of zinc and aluminum in the Tomogonops River, as it enters the Northwest Miramichi, are still cause for concern although, as discussed above for the site at Wayerton Bridge, dilution with the Northwest Miramichi brings the concentration of zinc significantly lower.

(iv) Group III Sites

Analyses by MREAC indicate no apparent problems for sites in this Group although problems could develop if the waters became more acid as the levels of aluminum are more than 100 µg/L in 22 of the 24 samples analysed.

Figures 23-27 show the concentration levels of copper, zinc, lead, aluminum, and iron in water samples taken from the Napan River, the Black River, and the Baie du Vin River all of which flow directly into the Miramichi Estuary along the South bank. With the exception of aluminum, all other metals either close to, or below, the levels recommended in the C.F.Q.G. Whether the aluminum levels become cause for concern will depend on whether the pH drops below 6.5. The median levels for the Napan and Black River are 6.5 and 6.6 respectively; the median level for the Baie du Vin River is 7.3. It is clear that the first two rivers are either at, or very close to, the level at which aluminum could start to pose a problem.

It is recommended that the pH be monitored on a regular basis for the Napan and Black River on a year-round basis with particular attention being paid when the level dips below 6.5.

(v) Group IV Sites

Analyses by MREAC show several samples from Sites 6 and 7 (Enclosure Park and Newcastle) where all metals are well above the guidelines. In view of the mixing with saltwater, however, and the increased hardness, it is unlikely that the levels shown for these sites or for the transect sites across the mouth of the Northwest Miramichi (Sites 32-35) and the mouth of the Main Southwest Miramichi (Sites 36-39), pose any problems.

Figures 28-33 show concentrations of copper, zinc, cadmium, lead, aluminum and iron at the upper estuarine sites of Enclosure Park (Site 6) and Newcastle (Site 7) and across the mouths of the Northwest Miramichi River (Sites 32-35) and the Main Southwest Miramichi River (Sites 36-39). Although the two lower sites in particular (at Enclosure Park and Newcastle) show several cases of concentrations well above the C.F.Q.G., the toxicity of these higher levels is greatly reduced due to the significant increase in water hardness (about 10 times higher than in most upriver sites).

Probably of greater significance in estuarine conditions is the level of metals that accumulate in various organisms and in the sediment. In view of this several samples of fish and shellfish were analysed from these sites and from the sites lower down the Estuary and the Inner Bay (Sites 40-45). The biota and sediment samples are discussed in the following Sections.

3. Acidity (pH) and other factors

The acidity (pH) recorded at various sites, is at a low enough level to be of concern. Further decreases, due to acid precipitation, could have disastrous consequences.

The level of acidity/alkalinity is usually expressed as the concentration of hydrogen ions or pH. These values range from pH = 1 (very acid) to pH = 14 (very alkaline) with a pH = 7 being neutral. As is indicated in the previous section, pH values below 6.5 can render certain metals, like aluminum, much more toxic than at higher pH values where, usually, less metal is dissolved.

As with metal concentrations, average or median pH values have little meaning in the absence of information about the range of values above and below. The median pH values for all freshwater sites sampled during the MREAC study are shown in Table V along with median values for dissolved organic carbon (DOC), water hardness, and temperature. All of these factors can play an important part in determining the toxicity of metals.

In general, toxicity of metals increases with decreasing pH and low pH alone is toxic as well. The situation, however, is very complicated. For example, dissolved organic carbon (DOC), which consists mostly of naturally present humic and fulvic acids, also lowers pH. In this case, the humic and fulvic acids may, at the same time as lowering pH, bind heavy metals thereby rendering them less toxic. Similarly, toxicity of metals decreases with increasing water hardness. For example, for water that is "soft", or under a hardness value of 60 mg/L of calcium carbonate, throughout most of the Miramichi system, the "safe" level for copper in the C.F.Q.G. is given as 2 µg/L; for water considered to be very hard or with a hardness value of over 180, the "safe" level for copper in the C.F.Q.G. is given as 6 µg/L, a three-fold increase; temperature, on the other hand, has the reverse effect in that as temperature decreases, within the physiological range for the organism, so does metal toxicity decrease (Not only is the metal less soluble at lower than at higher temperatures but, in addition, the metabolic rate of fish and other poikilothermic (often referred to as cold-blooded) organisms decreases as temperature decreases and hence less metal is taken in).

In addition to the pH readings taken at the different sampling sites and recorded in Table V, measurements were also made at four sites during the snowmelt period in 1990. These individual values are recorded for the appropriate dates between April 7 and May 14 in Table VI. As can be seen, the pH had dropped below 6.5 by April 22 until May 8 in the headwaters of the Main Southwest Miramichi at Deersdale, a period of at least 17 days. Similarly the pH had dropped below 6.5 on April 9 until at least May 2 at Stewart Brook which flows into the lower reaches of the Northwest Miramichi River, a period of at least 23 days. Readings at McGraw Brook in the Renous System and at Bryenton in the lower reaches of the Main Southwest Miramichi show occasional pH depressions below 6.5 but these were of much shorter duration and, given

the time of year with lower temperatures, are not of much concern.

The long period during April - May with low pH values and the median pH value of 6.5 for Deersdale (Table V) is of real concern as this indicates an unhealthy environment in the headwaters of the Main Southwest Miramichi River. In addition to the problems caused by increasing toxicity of certain metals that might be present, as the pH drops below 6.0 it can have adverse chronic effects on reproductive success of fish and aquatic invertebrates. There is no extended pH range within which Atlantic salmon, for example, will be unharmed (although the range 6.5 - 9.0 is given as a "safe" range in the C.F.Q.G.), rather there is progressive deterioration and greater risk of harm as the pH drops below 6.5 or rises above 9.0. Table VII provides an indication of lowered pH effects on various fish species without reference to other effects.

It should be kept in mind, however, that if the pH is lowered by such organic acids as humic or fulvic, as it is in brown bog waters for example, metal toxicity is not increased. The real concern relates to a lowering of the pH by inorganic acids such of nitric or nitrous and sulphuric or sulphurous which are present in acid rain.

The combined effects of low pH and increased metal toxicity are considered to be much more important than pH alone and are likely to cause problems for Atlantic salmon long before the pH reaches 5.0 where the acidity alone prevents reproduction. Neither suspended solids nor total dissolved solids are of any concern within the freshwater system, based on the MREAC data.

4. Organic and suspended materials

A substantial quantity of organic materials are discharged into the Miramichi River System on a daily basis. In the freshwater part of the system, such discharges take the form of sewage and household wastes as well as other discharges from municipalities, small industrial operations, and run-off from forest operations, such as pesticide and herbicide spraying, and from road construction.

Suspended solids are well within the C.F.Q.G. of 10 mg/L at all freshwater sites, the highest average being recorded at Blackville (7.2 mg/L). Similarly, from results available, there does not appear to be any problem with organic chemicals in solution at the freshwater sites sampled.

Accumulation of substances in the tissues of organisms and in the sediment of the river bottom are good ways to determine the impact of longer-term exposure to such substances. Analysis of various organisms and sediments has been made and will be discussed separately, in later chapters.

(a) Estuarine sites

The major sources of organic discharges into the Miramichi System are situated at the mouths of the Southwest and Northwest Miramichi Rivers and on the banks of the Estuary. Because of the difficulty in interpreting the toxicity of certain substances in salt water, and to determine the impact of longer-term exposure to such substances, both animal and sediment samples were collected and analysed. As indicated above, these analyses will be discussed elsewhere. Much attention has been paid to the potential detrimental effects of the major discharges into the Miramichi River System and at a meeting held in June, 1990 in Newcastle, N.B. between members of the MREAC and various Provincial and Federal agencies, Environment Canada (Industrial and Shellfish Programs Division) and the Provincial Department of Municipal Affairs and Environment agreed jointly, to sponsor a survey dealing with 15 sites representing point source discharges into the Estuary. A summary of the findings of the survey is presented in Table VIII. Each of the individual point sources is discussed briefly below with respect to potential problems. Although several other parameters were examined, where possible, the five major parameters measured during this survey were: 1. Biochemical Oxygen Demand matter (BOD_5); Suspended Solids (SS); Total Phosphorus (T.P.); Total Kjeldahl Nitrogen (TKN); and Faecal Coliforms (F.C.).

Miramichi Pulp and Paper Inc. (Newcastle)

The mill effluent was tested on four separate days in the summer of 1990 for BOD_5 and Suspended Solids (Solids). When the tests were compared to the Provincial Permit levels and the Federal Guidelines, which are different, the results were:

Provincial BOD_5 Limit	1 of 4 tests exceeded by 15%
Federal BOD_5 Guideline	0 of 4 tests exceeded

Provincial Solids Limit	0 of 4 tests exceeded
Federal Solids Guideline	2 of 4 tests exceeded (25% and 44%)

One "water flea" and two fish (bioassay/toxicity) tests were done on the effluent on two different days in summer 1990. The test defines a PASS as more than half the fish or fleas living in full strength mill effluent for 96 hours. The effluent passed the three tests. Fish test results from the company during 1989-90 showed 5 of 7 tests passed while two failed.

This mill was clearly the source of dioxins and furans which were measured in biota by Fisheries and Oceans Canada and the MREAC.

Miramichi Pulp and Paper Inc. (Nelson)

The effluent was acutely toxic to rainbow trout even when diluted to a concentration of only 12.5% of effluent with all fish dying within 18 hours. At 6.25% effluent concentration, four of the ten fish died within 96 hours. No cause was given for the mortalities, based on the chemical analysis, but it should be noted that the acidity of the effluent was low (pH = 5). This acidity, in combination with resin acids, was probably enough to cause the mortalities. The high level of aluminum (440 μg/L) at the low pH might have been a contributing factor.

The test using Daphnia magna also failed with all animals dying in full strength effluent within 48 hours and 9/10 dying at 32% concentration of effluent.

Town of Newcastle

Although there is a treatment plant for municipal waste, about 40% of the total waste is discharged directly into the Miramichi Estuary. The treated portion is well within the Provincial objectives. Both the untreated portion, however, and the combined total discharge, do not meet provincial objectives.

In sample 1, the BOD_5 loading, in the untreated portion, of 45 mg/L is 125% over the Provincial Guideline Limit of 20 mg/L. Suspended solids in the untreated portion, at a concentration of 60 mg/L, is 200% over the Provincial Guideline Limit of 20 μg/L. Combining both treated and untreated discharges results in daily loadings of 165 kg/day of BOD_5 and 191 kg/day of suspended solids. This represents an excessive loading of over 17% and 34% respectively.

Second and third composite samples also gave excessive BOD_5 and SS levels: The treated portion of each sample was well within the Provincial Guideline Limits whereas both the untreated portion, as well as the combined total of treated and untreated waste, had BOD_5 levels and SS levels well in excess of the set limits.

In the second sample, the untreated portion had a BOD_5 level 300% in excess of the limit and an SS level of 250% in excess of the limit. The combined loading of both treated and untreated waste in the second sample gave an excess of BOD_5 of over 86% above the limit and an excess of SS of over 54% above the limit. In the untreated portion, the third sample showed an excess

of 50% above the BOD_5 limit and an excess of 125% over the SS limit. The combined discharge (treated and untreated) showed excesses of over 26% of BOD_5 and 5% of SS. Neither total Phosphorus nor total Kjeldahl nitrogen levels exceeded the Provincial Guidelines Limits in any sample.

Village of Nelson-Miramichi

Discharges from the North Lagoon show higher levels of BOD_5, SS, T.P., AND T.K.N. than the South Lagoon when combined, however, the total discharge was within the established limits for all three samples with the single exception of total Kjeldahl nitrogen that was slightly higher (10%) in the second sample.

Eel Ground Indian Reserve

The facultative lagoon was not discharging at the time of sampling and the single sample taken was from near the decant pipe. The BOD_5 was within the concentration limits (12 mg/L) and the suspended solids slightly above (23 mg/L); the limits for both of these are set at 20 μg/L. There is a continuing concern with respect to seepage from the lagoon and the real possibility of the embarkment being washed out due to structural failure. Both the Indian Band and the Department of Indian and Iniut Affairs are aware of this problem but nothing has been done to address it to date.

Village of Douglastown

All the samples were within the established limits for all parameters measured with the single exception of suspended solids on the third day of sampling which was slightly higher (5%).

Atlantic Institute (Renous)

The lagoons were not discharging at the time of sampling but all BOD_5 and SS levels of the sample taken are within the Federal Guideline Limits, although the pH readings of 9.8 and 9.4 are considered to be on the high side.

Burntchurch Indian Reserve

In all three samples, the level of suspended solids was higher at 32 mg/L, 35 mg/L and 25 mg/L than the concentrations permitted of 20 μg/L. The overall discharge from this facility is relatively low, however, and does not pose a problem.

C.F.B. Chatham

In two samples, total phosphorus concentrations were slightly higher (3.48 mg/L and 3.18 mg/L) than the Provincial of limit of 3 mg/L. All other parameters measured were within the established limits.

C.F.S. St. Margarets

All parameters measured were within the guideline limits.

Village of Loggieville

Levels of all parameters measured exceeded the established Provincial Guideline Limits in at least one of the three samples taken. The concentration of BOD_5 was at the limit in sample (20 mg/L) and exceeded the limit significantly in both other samples (40 mg/L; 35 mg/L). In all three samples analysed, suspended solids (35 mg/L; 40 mg/L; 45 mg/L) exceeded the Provincial limit (20 mg/L).

In sample 3, the total Phosphorus concentration (3.53 mg/L) slightly exceeded the Provincial Limit (3.0 mg/L) and in Samples 1 and 3 the concentration of total Kjeldahl nitrogen (13.8 mg/L and 8.8 mg/L) exceeded the Provincial Limit (8 mg/L).

The daily discharge limits for BOD_5 materials and suspended solids were equalled or exceeded in all three samples; TKN exceeded the daily discharge limit in sample 1 (by over 82%) and in sample 3 (by only about 12%); T.P. exceeded the daily discharge limit only in sample 3 (by over 33%).

Atlantic Waferboard

All samples analysed were within the established limits.

Town of Chatham

Analysis of effluent from the treatment plant showed all measured parameters to be within the Provincial limits established.

Domtar Site

The run-off from this abandoned site was tested from the site run-off stream at the west end of the site and from the chemical stream at the east end of the site. With the possible exception of zinc, which probably did not originate from the Domtar Site and which measured 420 µg/L in the site run-off stream site at the Highway, all other metals and organics measured were either below the detection limits or below the guidelines established.

(b) Large Wastewater Treatment Plants

Concentrations of BOD5, SS, TP, and TKN are more-or-less acceptable from all three plants with a few samples exceeding Provincial Limits.

The three municipal treatment plants of Rogersville, Blackville and Doaktown were not included in the cooperative survey conducted by Environment Canada and NB Department of the Environment because they were outside the area of interest to Environment Canada from a shellfish consumption point of view. The results from all those plants are shown in Table IX.

The village of Rogersville has two wastewater treatment systems, both an aerated stabilization pond followed by a polishing pond. The Rogersville South (#1) system began it's operations in 1978 and has a design population of 1400; the Rogersville North (#2) system began operations in 1980 and has a design population of 480. They are **NOT** required to have a disinfection process before discharging to the receiving stream. Results of analysis for 1991 show that the Rogersville #1 system did not meet any of the standards in May but, with the exception of suspended solids, did meet them in August. This may be a result of the system not having had time to recover from the spring pond turn over before the sampling date in May. The Rogersville #2 system shows acceptable results except for TKN which is above the set standards.

The village of Blackville wastewater treatment plant consists of a facultative stabilization pond with a design population of 1400. Results indicate a higher than acceptable level of BOD and TKN. The high BOD result may not be an accurate indication of the efficiency of the system. A stabilization pond, even in good working order, may discharge a high level of algae which is not necessarily environmentally unacceptable but which has an impact on the results of a BOD analysis.

In 1990, the Village of Doaktown was operating their stabilization pond as a continuous release system whereas it was designed as a seasonal discharge system. Despite this, the effluent in July 1990 was essentially within Provincial standards. However, in late 1990 the method of operation was changed to seasonal discharge and, therefore, no samples could be collected at the effluent during the summer of 1991.

In order to maintain high water quality in the river, it is <u>essential</u> that wastewater treatment plants operate efficiently and meet Provincial standard limits. Where limits are exceeded, plants should be examined and, if necessary, overhauled or upgraded. The discharge of high levels of contaminants into the fragile, freshwater parts of the Miramichi is not acceptable.

(c) Small Sewage Treatment Plants

There are a number of small sewage treatment plants which discharge into the freshwater parts of the Miramichi River System. If these are operating properly, there is probably little in the way of deleterious effects on the river although as the overall loading increases, then so does water quality decrease. A survey of 14 such treatment plants by the MREAC with analyses for biological oxygen demand (BOD_5) suspended solids (SS) and faecal counts (FC) is summarised in Table X.

Based on several factors including: the results of samples taken, when possible and appropriate; visual inspection; and presence or absence of noxious odours; the overall operation of each site was rated as Good, Fair, or Poor. of the 13 sites, where a rating was appropriate 6 were "Good"; 3 were "Fair"; and 4 were "Poor". No comment is required for those plants rated good. Of the 3 rated "Fair", there was no chlorination facility at the North and South Esk High School treatment plant nor at the Kerr Mobile Home Park treatment plant and all three had concentrations of either BOD_5 or SS or both in excess of the Provincial limits. Of the four sites rated poor, neither the MacTavish Mobile Home Park nor the Millerton Estates Subdivision had a chlorination facility and the smell was bad also at the MacTavish Park and at the C.A. Clark Mobile Home Park. At all four sites, BOD_5, S.S. and F.C. were significantly high compared to the concentration limits established by the Province at 20 mg/L for both BOD_5 and SS values. The highest BOD_5 concentration (105 mg/L) is 425% greater than the established limit and the highest SS concentration (139 mg/L) is almost 600% more than the established limit. In all of the poorly-rated sites, the faecal coliforms were too numerous to count (TNTC).

It is recommended that the 'poor' and 'fair' rated plants be assessed carefully with a view to appropriate up-grading or the installation of new systems capable of handling present, as well as planned future, needs.

(d) Solid Waste Dumpsites

The only site of any concern is the closed dump at Strawberry Marsh where some contaminants still leach out into the river system. However, in view of the presence of salt water in the immediate vicinity, which buffers the metals, and in view of the high dilution that occurs, such contaminants probably do not pose any problem.

As part of the work on point sources which could affect the quality of the Miramichi River, the Committee collected information on 14 existing solid waste dumpsites, both closed and operating. The focus of the Committee was how these sites might affect the river quality through direct runoff so issues relating to air pollution and groundwater contamination were not investigated. Where no concern was identified about a site with respect to the river, it does not mean that there are no other environmental problems.

The dump sites associated with each of the two Miramichi Pulp & Paper mills are included in the Industrial Point Source Report because of their industry-specific nature and are discussed elsewhere.

Of the remaining 12 sites, the following 11 were assessed as having no impact on the river system: Parker Road, Quarryville, Loggieville, Astle, Nelson-Miramichi, Chatham, Doaktown, Bellefond Road, Blackville, Bushville, and Sunny Corner.

The only site with any impact was that at Strawberry Marsh which was examined and sampled five times (Oct. 26, 1988; May 30, 1989; June 28, July 4, and Aug. 30, 1990). Samples were taken from three of the leachate streams apparent at low tide and, when possible, from the marsh outlet.

Analysis of these samples showed concentrations of certain metals and of pentachlorophenol well above the C.F.Q.G. on some dates but not on others. In particular, a concentration of 348 µg/L of copper (more than seven times the lethal limit) and high, though not lethal, levels of zinc (202 µg/L, 359 µg/L) are cause for some concern even though there will be significant dilution. An ameliorating factor is the proximity to salt water and, accordingly, the buffering capacity that it provides.

The site is no longer used as a dump but, in view of the evidence of toxic leachates still present, regular continued monitoring is recommended.

5. MREAC Bacteriological Survey

Analysis of bacterial populations in the Miramichi System indicate that neither the Northwest Miramichi River nor the Main Southwest Miramichi River has high levels of faecal coliform bacteria. However, in several instances the faecal coliform count is much higher than would be expected and this is probably due to direct dumping of raw sewage into the River from private dwellings.

The acceptable limit, for recreational use such as swimming, of 200 bacteria per 100 ml is occasionally exceeded but there are several instances of counts between 100 and 200 bacteria per 100 ml water. Levels such as these are well above the expected values of 10-20 per 100 ml.

From the confluence of the two rivers at Derby Junction and down both shores, faecal coliform levels were much higher and the most probable number (MPN) per 100 ml of water ranged from 31 to over 2,400. Bacterial numbers were highest at the Chatham Bridge, decreasing progressively downstream. The public health standard requires that: "The most probable number (MPN) of faecal coliforms in water not exceed a median of 14 per 100 ml and that no more than 10% of the samples exceed 43 faecal coliforms per 100 ml in areas approved for shellfish harvesting." [See also Chapter 8 for discussion of shellfish harvest.]

Given the high bacterial discharges from the point sources identified above and shown, where appropriate in Table VIII, it is recommended that the entire upper estuary remain closed to shellfish harvesting on both banks. The most significant contributor to faecal coliform bacteria in the Estuary is the Town of Newcastle due, in large measure, to 40% of its sewage being discharged directly into the Estuary without treatment. Addressing the problems of some of the minor contributors will provide minor improvements with respect to BOD_5 materials, suspended solids, total phosphorus, and total Kjeldahl nitrogen.

To provide any major improvement requires that all municipal waste from Newcastle be treated. In line with this recommendation is the associated caution that no further loading be placed on a system already incapable of handling the present loading.

6. Bulk Petroleum Storage Facilities

There are six commercial bulk petroleum storage facilities in the watershed. The PetroCanada and Texaco ones are closed and unlikely to reopen. The Esso one is closed or will close soon. The facilities all had suitable dyking and were in reasonable repair. The Ultramar site had a concrete loading pad for catching spills during loading followed by an oil-water separator. The two Irving facilities in Newcastle and Boiestown did not have the pad or separator. The most significant threat to water quality from these sites is from a major spill due to failure of tanks or piping. Proper preventative maintenance and operator training are essential precautions to take in order to avoid what would be disasterous consequences from a major spill It should be realized that when such spills occur in rivers and estuaries, that the amount recovered would probably be less than 25%.

7. Water Levels

There is a widely-held view that water levels in the Miramichi River System rise and fall more rapidly than they used to because of clear-cutting operations in the watershed forests. In response to a request from MREAC, a review of historical discharge records in the Miramichi River Basin was prepared by the Surface Water Section of the Water Resource Planning Branch, Provincial Department of Environment and presented to MREAC on July 18, 1989 by Mr. James E. Anderson, Chief of the Surface Water Section.

In his presentation, Mr. Anderson commented on the effects that clear-cutting has on water discharge to the river. With respect to water quality, if the land is grubbed using heavy equipment, there will be an increase in suspended solids. However, buffer strips, required by Provincial regulation and adhered to by the Forest industry, would prevent this. Similarly if cutting were done in winter, this would also prevent any suspended solids from reaching the water. With respect to water quantity, clearcutting can either increase or decrease the net, long-term water quantity dependent on such factors as soil permeability soil moisture and type of forest cover. (e.g. a softwood forest replaced by a hardwood forest results in a long term increase and, presumably, a hardwood forest replaced by a softwood forest would result in a long term decrease.) the: "short-term effect of clear-cutting is an increase in both the runoff volume and flashiness of the runoff." Over time, for each area that is clear-cut, the "short-term effect will undergo a transition where the runoff decreases - the rate of decrease and the equilibrium level are dependent on both the type and growth rate of the revegetated forest cover, the soil permeability and the extent of the cut."

Road construction practices, at or near streams, are the major source of fine sand and silt runoff into rivers and streams. Although considerable improvement has taken place over the past five years, woodlots, crown lands, and government road construction are all in need of improvement. This kind of runoff is particularly destructive in the upper reaches to salmon redds in late fall and winter. At this time, eggs and developing larvae are in the gravel where they could be smothered and killed if overlaid by sand or silt.

In examining the above question, the MREAC study also looked at the dates of ice break-up over the last 2-4 years and the dates of the spring flow peak. These data are shown in Tables XI and XII for three sites from 1966-1989. If the ice break-up dates are plotted on a graph, despite the highly variable fluctuations from year to year, it is apparent that there is a general tendency for the ice break-up date to get earlier and earlier (Fig. 34).

CHAPTER 4

BIOTA ANALYSIS

With the exception of certain samples analysed, there do not appear to be significant chemical contamination problems in the biota sampled in the Estuary.

Due to several constraints, only a small, limited number of samples was available to the Committee. Added to this constraint were the considerable problems of obtaining suitable, and accurate, analyses with appropriate quality controls. What this means is that although conclusions drawn are based on the assumptions that (a) an adequate number of samples has been taken and (b) that the analysis is flawless, these assumptions may not prove to be valid.

1. Tissue analysis

(a) Heavy metals

Table XIII shows the concentrations of heavy metals in the biota from the Miramichi River System. White sucker and striped bass near Beaubear's Island showed levels of mercury higher than the level that children and childbearing women should consume but at levels safe for limited consumption by others. Zinc levels are high in oysters but do not threaten consumers. Levels of mercury in tomcod and flounder appear about twice as high as those found in 1970 tests by Sprague and Carson but different locations and test methods may account for some of the difference.

All of the metal data in Table 1, except the mercury results, were provided to Dr. B.L. Huston, Chief of the Health & Welfare Canada Chemical Evaluation Unit for review. In assuming: (a) the moisture content of the biota was 10%; (b) the sampling was representative; and (c)* the laboratory analysis was done properly, he concluded that the cadmium, copper, lead, and zinc levels in the samples would not pose a threat to human health. He also suggested that in future testing, the detection level for lead should be lowered to 0.1 PPM dry weight instead of the 5.0 PPM dry weight used.

More work on mercury content of selected species is recommended.

(b) Chlorinated dibenzodioxins (dioxins) and dibenzofurans (furans)

Table XIV shows the concentrations of dioxins and furans in the biota samples from the Miramichi River System.

Dioxin levels found in whole white sucker by MREAC in 1990 near Beaubear's Island were lower than those found by Fisheries and Oceans Canada

* This assumption applies to all analyses.

(DFO) in 1989. White sucker fillet levels were much lower than whole fish levels. The testing showed lobster hepatopancreas (tomalley) and white sucker with the highest levels of 2,3,7,8 TCC dioxin. The lesser toxic forms of dioxin were at low levels. The pattern of TCDD dioxins indicates the principal source to be pulp mill chlorine bleach plant discharge rather than contaminants in the wood preserving chemical PCP which would be high in OCD dioxins.

Health & Welfare Canada (HWC) reviewed the concentrations and consumption patterns of the species in Table XIV and determined that a health advisory warning was not required because (a) lobster tomalley is not eaten in sufficient quantity and (b) white sucker is not a commercial species. However, both species show significant accumulation of dioxin.

As the pulp mill bleach plant makes planned equipment changes to eliminate dioxin discharge, these two species should be monitored for expected decreases in dioxin levels.

(c) Pesticides

Table XV shows the concentrations of pesticide or pesticide residues in the biota samples from the Miramichi River System.

The species sampled are the better bioaccumulators of pesticides in the estuary but none of them showed any significant levels relative to any of the limits cited. DDE was found in most samples at low levels indicating the breakdown of DDT used in the past.

(d) Chlorophenolic compounds

Table XVI shows the concentrations of chlorophenolic compounds in the biota samples from the Miramichi River System.

No published limits are cited in Table XVII since none is specified in Canada. Chlorophenols could originate from both wood preserving plant effluents and chlorine bleaching pulp mill effluents. Chlorocatechols, chloroguaiacols, chloroveratroles, and the others would originate from the chlorine bleach process.

The levels found were low overall and usually near or below the detection level of the laboratory.

(e) PAH^S

Table XVII shows the concentrations of polynuclear aromatic hydrocarbons (PAH^S) in the biota samples from the Miramichi River System.

PAH levels were low in the species tested, usually at the detection level with lobster hepatopancreas (tomalley) showing measureable levels. Fin fish were not tested because they can metabolize or break down PAH molecules. No

USEPA (Environmental Protection Agency) limits exist for PAH in aquatic biota for consumption.

(f) PCB^S

Table XVIII shows the concentrations of polychlorinated biphenyls (PCB^S) in the biota samples from the Miramichi River System.

The species tested were the ones most likely to accumulate PCB. The levels in the biota tested were low compared to the allowable limit. The type of PCB's found indicate that there is no current source going into the estuary and that the ones present. are from past activities.

(g) EOX

Table XIX shows the concentrations of extractable organochlorines (EOX) in the biota samples from the Miramichi River System.

No limits are set and little is known about EOX in biota. The principal source of EOX in the estuary is probably the chlorine bleach plant at the MPPI kraft mill. There are also natural sources but their contribution is unknown. EOX are a family of 200 to 300 chlorinated compounds with an extremely wide variety of properties and toxicities about which little is known. In the mussel samples taken, there are estuary results both above and below the control samples taken at Big Tracadie River, away from any pulp mill source. Given the values in the Big Tracadie mussels, it would be difficult to say there is any buildup of EOX taking place in the estuary mussels.

The references used and referred to above are listed in Table XX.

Although there do not appear to be any serious contamination of the biota at the present time, it is recommended that: (1) Additional analyses for mercury be conducted on finfish near Beaubear's Island in 1992/1993 to compare with present results from white sucker and striped bass; (2) Continued monitoring for dioxins and furans be conducted for lobster tomalley and white suckers over the next 10 years to track the planned decrease of chlorine bleaching at the MPPI kraft mill; (3) Additional analyses of biota for organochlorines, PAH^S and their metabolites; and (4) Continued surveillance for unidentified organics.

2. Benthic Faunal Communities

Although much information can be gained on the quality of a habitat, by measuring the levels of various contaminants within that habitat, the real crucial test is whether the populations of organisms that normally live there are still there and are alive and well.

(a) Introduction

The single, most difficult task in assessing the health of a habitat, through sampling those organisms that should live there, is in the interpretation of results. As is clear from the literature, many studies have been conducted in the past to determine what organisms are present in various parts of the Miramichi River System and as is equally clear, the interpretations, based on similar data, are often different. There are many problems inherent in this approach to determining habitat health and some of these are summarised below to provide a better understanding of the limitations of such studies.

Two important parameters usually measured are: (1) The number of different species found; and (2) The number of individuals, per unit area or volume, that are present. From the first parameter, further distinctions can be made as to the sensitivity or resistance of the species present, to the contaminants in question. Thus, although there may be several species present, if those species sensitive to lower levels of a toxic contaminant are absent, it may be because that particular contaminant has killed them off or they simply were not found. Whether any particular species is found or not is highly dependent on the sampling method used, on the time of day, on the season of the year and on the ability of the investigator to identify the organism. As most organisms have life cycles with different stages present at different times of the year, the absence of adult mayflies, for instance, in a sample collected in August, does not mean that the species is absent as it could easily be present in the egg or early larval stage but not be detected. Many organisms have special microhabitats that they occupy within a major habitat, like a river, and this requires meticulous care and extensive knowledge for any sampling study to be meaningful.

Frequently, a species diversity index is constructed to compare results from a different geographical sites with a view to determining that one site is healthier than the other; such an index can also be used to compare results from the same site but from different years. This is a powerful instrument if used properly. Unfortunately, and all too frequently, it is not used with adequate care. For example, if a study reports a species diversity index of 5 species for site A and 10 species for site B and concludes that site B is a better habitat, this could, indeed, be true if the numbers of species identified for both sites were actual species.

Due to the great difficulty in identifying certain groups of organisms and the decreasing

> numbers of taxonomic specialists, many studies will simply show identification to the genus level or, even worse, to some even higher taxon, that could contain a thousand or more species.

Thus, in the study of sites A and B above, if the identifications of organisms in A include higher levels than the species (such as: to the genus Salvelinus sp, which contains several species; or to the Family Salmonidae, which contains many species) then the conclusion reached that B was a better habitat may not be true based on the number of "species" present. The example above would seldom prevail as it is relatively easy for most biologists to identify different fish species. Most reports, however, do not identify all insects found to the species level, because of the specialised knowledge required and the same is often true for other invertebrates such as aquatic oligochaete worms and aquatic mites.

(b) MREAC Study

The MREAC benthic invertebrate study was started in the spring of 1989 to complement the water chemistry and point source discharge programs to determine the health status of the surface waters of the Miramichi River System. This status report provides a framework and template for future studies and exercises that can identify and solve any problems present.

Analysis of the benthic insect communities at 10 selected sites (Map 6) indicated, in general, that healthy communities were present in the upstream sites at Juniper Station, Bloomfield Ridge, and Boisetown on the main Southwest Miramichi River, at Wayerton Bridge on the Northwest Miramichi River, and at Lyttleton Bridge on the Little Southwest Miramichi River.

Possible problem areas included the downstream sites at Doaktown and Blackville on the main Southwest Miramichi River and in the Nappan River that flows directly into the Inner Miramichi Bay on the south shore. In these three locations, both insect diversity (number of species) and insect density (numbers of individuals) showed unnatural declines at various times throughout the collection period.

Relatively few insect species were found at the mouth of the Southwest Miramichi River and of those species present, the numbers of individuals were low. The situation at the mouth of the Northwest Miramichi River is even worse with only a small number of guats appearing in July and disappearing in August. The low diversity of species and the few numbers of individuals has been interpreted in various ways in different reports which have variously stressed the nature of the substrate and the influence of salt water. One factor that has been ignored until now is the fact that the sediment at these locations contains relatively high levels of heavy metals which, when acting together, provide levels (Refer to Chapter 5) well in excess of the guideline limits.

In view of the above, the following recommendations are made:

(1) Sample benthic invertebrates at various sites, selected on the basis of their possible role in contributing contaminants to the Miramichi River System.

(2) Incorporate into such sampling the use of "pot samplers" that should be placed above and below the point sources of potential problem discharges.

(3) Sample water from the same sites as above for analysis of heavy metals and other parameters selected on the basis of potential problems identified in this report.

CHAPTER 5

SEDIMENT ANALYSIS

Contaminants in sediments below the Chatham (Centennial) Bridge in the lower Miramichi Estuary and in Miramichi Bay present no risk to the environment. Heavy metals in sediments in the upper Miramichi Estuary, from the Chatham Bridge to the confluence of the Southwest Miramichi and the Northwest Miramichi and the Northwest Miramichi and some distance up the Northwest Miramichi, are above the marine sediment guideline, and may be adversely affecting aquatic biota.

Analysis of the sediment was based on 18 samples from Miramichi Bay, 20 Seatech samples from the dredged channel, and 23 MREAC samples.

Most of the samples analysed were from the lower estuary, below the Chatham Bridge; data from the upper estuary (above the Chatham Bridge) and from freshwater are limited.

Table XXI shows the range of guidelines, present in different regions, for metals, PAH^S and PCB^S. In assessing the risk of heavy metals (copper, zinc, cadmium, mercury, and lead) in the sediment, the Washington marine guideline was used and the risk assessment itself is based on the "toxic unit" concept discussed in Chapter 3. This takes into account the total, additive, effect of all metals combined. Individual toxic limits were used in assessing the risk due to PAH^S or PCB^S.

Table XXII lists the sediment sample sites in order of decreasing toxicity due to heavy metals. As is apparent, the risk from heavy metals in the lower part of the Estuary (below Chatham Bridge) is relatively low; however, the risk from heavy metals in the upper part of the Estuary (from the Chatham Bridge to the Morissey Bridge) is considerably higher. Unfortunately, data for this upper region are limited. Samples 92, 50, and 51 are considered "outliers" because of abnormally high lead (Pb) concentrations. Most of the samples numbered 71 and higher were analysed by one laboratory and may include a laboratory bias.

Table XXIII shows the levels of PCB^S and PAH^S expressed in $\mu g/kg$ of dry sediments and in $\mu g/g$ (=mg/kg) of organic carbon for comparison with the toxic limits given in Table XXII. Only one sample at Chatham (16 $\mu g/gC$) exceeds the toxic level (12 $\mu g/gC$) for PCB^S; all the PAH levels are well below the toxic limits of 370 $\mu g/kg$ and 960 $\mu g/kg$ organic carbon, the highest values only reaching 145 $\mu g/kg$, except for a single sample at site S8 which showed an exceptionally high level of 61,489 $\mu g/kg$. This single test result has the same mix of PAH Compounds as the lower test results which gives it credibility.

Six of the Estuary sediment samples were bioassayed using amphipod, mussel larvae, and the Microtox tests. None of the samples was toxic to the

amphipods; two were toxic in the mussel larvae test; all were toxic in the aqueous extract Microtox test and in the ethanol extracts. There is a lack of comparative data for the Microtox test with sediment extracts, however, and these data are not considered at this time. The results of these bioassays are in agreement with the risk assessment above.

In view of the heavy metal toxicity of sediment in the upper Miramichi Estuary and in the Northwest Miramichi, the sediments should be sampled on a finer grid to outline the polluted areas for a more definite and better defined risk assessment. In addition, in view of the high PAH level present in one sample (site S8), this area needs multiple additional samples, and possibly sediment bioassay, to assess better the significance of the result.

CHAPTER 6

DREDGING

Clear-cut conclusions about the biological effects of dredging may never be reached. A common sense practice would be to limit dredging to a minimum after a cost/benefit analysis.

Records of dredging in the Miramichi estuary go back to 1872. More than half of the dredging was performed in the Inner Bay. The largest operation, The Miramichi Channel Dredging Project in 1981/82, removed about three times the amount of previous spoils. Most of these were deposited at the site B in the Inner Bay. Maintenance dredging, on a considerably smaller scale, has continued since then.

The effects of the dredging were the subject of a large number of studies, recently summarized by a Workshop organized by the Acadia Centre of Estuarine Research in 1990 and only the main conclusions are given here.

Apparently a lot of hydrographic data was collected prior to 1981, but not evaluated in detail and much of it might have been lost.

Only small amounts of sediment accumulate in the "river portion" of the estuary (from Beaubears Island to Loggieville); but, in the Inner Bay, the sediment accumulates at a rate of about 0.03 cm per year (120,000 m/3). The sediment is relatively rich in organics (2.3 and 6.7% for the river and bay sediments, respectively). Much of the organic content can be attributed to wood fiber and related waste, as about 20,000 tonnes/year were discharged to the estuary between 1950 and 1977. The high organic content of the sediments makes contaminants less bioavailable and there is recent evidence that it tends to "stabilize" the sediments, but relatively little is known about the fate of sediment resuspended as a result of dredging.

Two recommendations that emerged at a meeting of those involved in the Miramichi Inner Bay Stability Study are as follows:

(1) In order to determine the rates of consolidation of freshly dumped materials within Dumpsite B, further field work is required next fiscal year. Further field and laboratory work to detect the level of suspended solids during a period of dumping of dredged materials are required as well.

(2) It was recommended that Submerged Optical Backscatter Sensor Array 9SOBS) be deployed near the channel for a month during dredging to evaluate the potential of generating a fluid mud. In order to determine long-term seabed stability under storm events and ship passage, further studies will be required.

There is a lack of data on the effects of dredging on the aquatic life in the estuary. The data are limited mostly to increased incidence of fouled fishing gear and claims of catch reduction. Commercial catch statistics would be a very good monitoring tool but it is surprising how difficult it is to

gather these data.

> **Monitoring systems for water quality, sediments, and biota should be implemented along with maintenance of a database of catch statistics for the fisheries. This would provide the required basis for many decisions regarding further impacts on the Miramichi River System as well as decisions relating to dredging. In view of the heavy metal concentrations in the sediments of the Upper Estuary, dredging in this part of the System should not be undertaken without very careful consideration of its effects.**

CHAPTER 7

THE ATLANTIC SALMON

The sensitivity of Atlantic salmon to heavy metals and to low pH caused by acid precipitation are of real concern. Great care should be taken to reduce further any metal contamination of the Miramichi River System and efforts must be maintained to reduce acid rain caused by long range transport of pollutants.

1. Anecdotal

The history of salmon in the Miramichi has roughly parallelled the history of the river itself. Early reports on the river indicate unbelieveably large runs of salmon into the river. The decline has not been a steady one. There have been low populations of salmon in the past, but looking at the overall picture, the trend is obvious: decline, decline, decline.

The prominent place of the salmon in the culture of the Miramichi cannot be overemphasized. Thousands upon thousands of New Brunswickers spend their time talking about, planning for, preparing for, and finally actually going fishing on the Miramichi. All upriver, riverside communities have large numbers of people with an intense interest and passion for this sport.

The salmon has almost assumed a ritualistic role in the homes of Miramichiers. The first bright salmon caught was an occasion to be celebrated by a gathering of friends and family to share in the first bounty of the coming season. Exclamations of pure delight always accompanied the sensation of that first bite into the bright pink flesh of the first fish.

There is another culture on the River based on the poacher. Many a tale is told of a close call; of running through the alders with the wardens in hot pursuit. It was a sign of impending manhood to be allowed to take part in this summer rite.

Sadly, the culture of the commercial fishermen/farmer has disappeared from all but the Bay area. Gone are the times of excitement and anticipation when men prepared their box nets for the coming season and little boys hung close to grab whatever bits of excitement fell their way. Bringing home a freshly caught shad, bass, or grilse was a sure way to earn favour with an appreciative mum once the fishing actually got started.

To yet another group, it is simply enough to know that the mighty salmon is well. The delight of seeing the salmon jump, run a rapid, or spawn in the fall is enough. All is well with the Miramichi if all is well with these, its most respected and revered, citizens.

Unfortunately, all is not well. Many many Miramichiers share a deep frustration, a gnawing hatred for those who have allowed, or caused, the decline of the salmon in our rivers and streams. Their sense of betrayal, of outrage is ever present waiting for an opportune time to be expressed.

2. Historical

The huge runs of Atlantic salmon (Salmo salar) in the Miramichi River are legendary. For many reasons (including the natural beauty of the fish, its fine taste, and the mystical nature of its migration) salmon has been in strong demand through the years. This, in turn, has led to such over-exploitation that with the drastically reduced numbers there is concern over the very survival of this species, in its natural state, in the immediate future. In addition to the serious exploitation of salmon over the years, their habitat has also been subject to various stresses and contaminated to the point that their normal reproductive cycle has been interfered with on several occasions. With the opening of the copper and zinc mine in the Tomogonops River watershed over 30 years ago, early levels of these metals in the Northwest Miramichi were high. This caused adult fish, on their way upstream to spawn, to turn round and go back downstream. From 1960-1963, over 1,000 fish were counted at Curventon, on their way back down before spawning. Of these, about one third eventually reascended the river going back through the counting fence at Curventon. A few were caught by angling below the fence or in other tributaries, and a few were caught commercially in the Miramichi Estuary. For over 60% of those fish that returned downstream, however, there is no further record. This represented a serious loss to the spawning population of Atlantic salmon in the Northwest Miramichi. The discharge of pulp mill effluents at the mouths of the Northwest and Southwest Miramichi Estuary further stressed the estuarine habitat, putting yet another strain on the salmon which accumulate in the Estuary as smolts, before going out to sea, and which frequently spend extended periods in the Estuary as adults, waiting for a rise in the river level, before going upstream to spawn.

As can be seen in Fig. 35, recorded catches of Atlantic salmon from the Miramichi between 1951 and 1990 have declined overall even though there are significant fluctuations from year to year. A brief respite in commercial fishing between 1973-1975 and the complete cessation in 1984 did not bring the expected return of the previous large populations of salmon to the river. No explanation is presently available to account for this although it must be remembered that adult fish feed and grow in the waters off Greenland, where they are subject to fishing pressures, and that they return to the Miramichi by way of the Newfoundland Coast where they could suffer further fishing pressures.

The active Atlantic salmon research program on the Northwest Miramichi, which started in 1960, was terminated by DFO in 1973 just as the mining operation on the Tomogonops was developing a new treatment system. That the effects of the new system could not be carefully monitored, due to the cancellation of the salmon research program, is extremely unfortunate and a sad reflection on the decision makers of the day. Some monitoring, however, has been continued by DFO using fish traps at their Station at Millbank and in the Northwest and Southwest Miramichi. Estimates, by DFO, of "grilse" (fish that have spent one winter at sea) and "salmon" (fish that have spent more than one winter at sea) returns, show that the number of grilse far exceeds the number of salmon in the Miramichi System (Fig. 36) and that the high returns of fish in 1985 (following the closure of the commercial fishery) have declined substantially by 1990.

3. Present

In spite of the plight of the Atlantic salmon in the Miramichi, in spite of their reducing numbers and in spite of the stresses on their environment, over-exploitation continues by way of the uncontrolled native food fishery. Since 1990, numbers have been reduced significantly and neither the Federal Government nor the Provincial Government appears able to take responsibility for the conservation of this invaluable species. It is clear, from a comparison of metal levels in the Northwest Miramichi, that recent average levels are much lower than previous average levels due to improvements at Heath Steele Mines who should be commended for this. It is still the case, however, that spills, accidents, or other problems can and do occur from time to time, which result in large-scale toxic discharges that are potential problems throughout the Northwest Miramichi River. Safeguards must be in place to prevent shortages of lime (1988) and the spill (1991) from happening again.

Continued habitat destruction, pollution and illegal fishing will all put stress on the salmon populations. Until these issues are addressed and mitigated so that impacts on the fish are reduced and insignificant while still meeting all the needs of the users, the images of those vast numbers of fish and quiet leisure-time fishing will be only in those minds of people old enough to remember.

It is strongly recommended that the custody of the Atlantic salmon in fresh and estuarine waters be assumed by the Provincial Department of Natural Resources with a full mandate for their conservation first.

CHAPTER 8

SHELLFISH HARVESTING

More and more molluscan shellfish habitat is being closed to shellfish harvesting because of untreated sewage. Communities, and private home owners, should be required to use appropriate sewage treatment facilities and "clean up their act".

Both Miramichi Bay and the Miramichi Estuary provide good habitat for molluscan shellfish such as clams, mussels, and oysters. These have been harvested both commercially and privately for a great many years. It is clearly important that the shellfish harvested, either commercially or privately, do not cause any illness when consumed. From a commercial viewpoint, it is also important to maintain both high quality standards and public credibility regarding these standards.

The main method used to determine the safety of molluscan shellfish, for human consumption, is to measure the number of faecal coliform bacteria in the water in which they live. This is because shellfish, such as clams, mussels, and oysters, are filter-feeders which concentrate any minute particles in the water (using cilia on their gills) and then transfer these as potential food into their intestine. Thus, even if there is a relatively low density of potential pathogens in the water, because of the feeding action these become highly concentrated in the shellfish. The present standards require that the number of faecal coliforms in the water not exceed 14 per 100 ml water. This is an average number from several samples (usually expressed as the Most Probable Number or MPN), among which no more than 10% exceed 43 faecal coliforms per 100 ml water. In addition to actual counts of faecal coliforms, all sources of contamination for a shellfish area are evaluated with respect to their potential contribution of faecal coliforms to that area. All information is then evaluated and a decision made with respect to suitability for shellfish harvesting. The categories used are: "Approved"; "Conditionally approved"; or "Closed".

Bacteriological surveys have been conducted for more than 20 years in the Miramichi area and in 1971, the area upstream from Oyster River and Point au Carr was closed. Further closures were imposed in 1985 and in 1990 with all areas upstream of a line running from Oak Point to Point au Carr being closed.

Many factors contribute to the closure. As indicated in Chapter 3, a major contributor to the lower Estuary is the untreated bypass from the town of Newcastle which dumps about 40% of its sewage directly into the River without treatment. In addition to the lack of disinfection at Newcastle, disinfection facilities do not exist at Chatham, Nelson Miramichi, or Loggieville. Direct discharges from individual dwellings, not served by sewage systems, add to the problem. Other factors include contaminated run-off from agricultural operations particularly in the Nappan River and Bay areas.

Along the south shore, additional closures to shellfish harvesting are in

effect in the Black River and Baie du Vin River. In both cases, contamination due to agriculture run-off is the primary factor. Several sections of the adjacent south shoreline are becoming suspect owing to the proximity of cottages discharging raw, or inadequately treated, sewage directly onto the shore. A recent closure at Baie du Vin beach resulted from high faecal counts originating probably from a combination of small agricultural operations and private cottages. A closure is in effect downstream of the lower Hardwicke River Bridge because of the wharf facility there. Other closures at Eel River and Portage River also exist due to the cluster of contaminating sources present. The wharf facility and fish processing plant were causes, recently, for closing an area in the vicinity of the Escuminac wharf.

The north shore of the Miramichi Bay, a closure is in effect to the east (2,200 m) and west (1,600 m) of the mouth of the Burnt Church River. This was necessitated due to the high faecal coliform counts resulting from inadequate maintenance and operation of the sewage treatment plant at the Burnt Church Reserve. the closure at Neguac, in the vicinity of the government wharf, is due to contamination from a fish processing operation and that at the mouth of McKnight Brook in Lower Neguac is associated with a cluster of 10 cottages and the sewage they produce.

Although the number, and extent, of shellfish areas closed because of pollution have increased. It is important that the public understand the causes for these closures.

Much work is required by the Provincial Departments of Health and Community Services, Environment, Agriculture and Municipal Affairs in cooperation with Environment Canada and the Federal Department of Fisheries and Oceans to correct present problems and prevent future closures. It is recommended that all the departments indicated above work together to identify one department with responsibility for both monitoring and regulating shellfish areas for harvesting.

CHAPTER 9

GOVERNMENT PROTOCOL AND LOGISTIC PROBLEMS

As will be clear from the list of MREAC members, several individuals from different government agencies worked tirelessly for the Committee. Even with their help, however, many frustrations persisted during the course of this study and to ignore these is to hide what the Committee perceives to be real problems that should be addressed. The following comments are not directed at individuals but rather at the "superstructures" of government agencies with their incredibly complex "infrastructures" and the difficulties experienced in what should have been simple communication.

There are two general themes that emerge over and over again: The first is the inordinate waste of effort caused by overlapping responsibilities of two or more government agencies; The second is the inaccessibility of some agencies due to distance from the source of the problem and poor organization. The experience of the Committee during this study strongly supports the conclusion that to divide responsibility is to have no one responsible. Each party leaves the job to the other. Because some agencies are distanced in space from the Miramichi, it was frequently difficult to maintain dialogue or even get answers to simple questions due to poor organization of communication. In support of the above generalizations the Committee offers the following specific problems and makes specific recommendations that would resolve them:

Problem 1: There has been a silting problem occurring in McKay's Brook located at the lower end of Strathadam. This problem was first reported several years prior to the formation of MREAC. In spite of repeated efforts by MREAC to get a satisfactory solution to this problem, at the present time, as this report goes to press, the problem has not even been looked at by any of the responsible agencies. These are: DFO - silting in streams; DNR - Forestry practices; Provincial Department of the Environment - setback zone from streams for the creation of a pit (in this case there is a sandstone pit located at the mouth of this brook); Federal Department of Indian and Northern Affairs - native issues (the Eel Ground Reserve has a small woods operation further up this stream).

Recommendation: Have only one, locally-accessible, agency responsible for dealing with pollution in streams, rivers and lakes. This agency should then be held accountable for any lack of action on any reported problem. This agency should also be required to report back to the individual or organization which originally reported the problem to inform of what action, if any, was taken.

Problem 2: During May of 1988 a major fish kill occurred on the Miramichi. The principal species involved were smelt and tomcod but other species were also killed. There was some delay before DFO got involved with the result that there was very little lab work done to determine the cause of this fish kill. The report that was generated by DFO to try to explain this event was inadequate at best. The conclusion reached in this report "that the fish had

died from natural causes" was not supported by the science that was directed at this problem. Elaborate analysis and examination of the fish by D.F.O. and the Atlantic Veterinary College of U.P.E.I., showed no pathogenic bacterial or viral infections but did show that the fish had substantial numbers of parasites. The level of parasitomia present would not be sufficient to kill the fish under normal circumstances although they would be stressed. If they were subject to additional stress, such as contaminants in the water, then they could die from the joint effect.

Recommendation: DFO needs to be much more intimately involved with the concerns of the Miramichi.

Problem 3: The report on the health of the stocks of Miramichi salmon submitted to MREAC by DFO was considered to be inadequate. Members of the committee questioned the accuracy of data that was being used by DFO to graph trends in populations of salmon.

Recommendation: There are a number of recommendations that are offered here to remedy this situation.

(i) Because of the many competing forces buffeting DFO, much of the science gets hidden. If DFO is to remain the primary organization providing lab analysis, then its science branch needs to gain independence from the rest of the organization. The mandate of this branch needs to be clearly established. This mandate should establish that a clear priority is given to the local aquatic ecosystems and the communities that inhabit them and it should also establish the exclusion of political considerations. Research and management control are not good bedmates!

(ii) DFO has inadequate field work taking place on the Miramichi to assess competently the status of the many different stocks of Atlantic salmon that run into the river. It is recommended that DFO direct more of its efforts towards scientific research on river systems and less effort on management and enforcement in the freshwater areas of these systems. As recommended elsewhere, Provincial agencies seem to be in a better position to carry out these functions of management and enforcement.

(iii) The Miramichi community should have well-publicized and local access to DFO and it should have its branch located on the river.

Problem 4: Early in the work of this committee following sampling by the Provincial Department of Environment there was a discovery made of high bacteria counts in the Taxis River near Boiestown. As a consequence of this, the Department of Health and Community Services were advised of the problem. They resampled and retested, but did not find a problem. After much discussion, it was discovered that the two departments have different sampling procedures. Even though the source of this waste still exists, no action has been taken.

Recommendation: Sampling and testing procedures need to be standardized;

there should only be one department responsible for the regulation of sewage systems regardless of the source.

Problem 5: During the study there have been numerous observations of sewage from both institutions and from private homes being discharged either directly to ditches or into watercourses. The Department of Health and Community Services approves all permits for construction of septic systems but is unable to do the necessary follow up inspections to ensure compliance.

Recommendation: This department (if it continues to have this responsibility) needs to initiate a program of regular checks of all sewage disposal systems including private homes to make sure they are operating properly. Adequate inspection staff must be provided. If a system is not operating properly, then an order needs to be given to comply within a specific time period. People who do not comply within the time period should have stiff fines imposed.

Problem 6: MREAC also undertook a survey of local swimming spots. It was discovered that the Department of Health and Community Services do not do any regular check of local swimming holes other than those located in provincial parks. This means that many people are swimming in areas of unknown water quality. Many simply do not swim in the Miramichi anymore because of this uncertainty.

Recommendation: There needs to be a periodic survey of the whole river so that the local population can check to find the probable degree of safety from pollution for swimming in any given area.

Problem 7: The committee was frustrated throughout the study by the lack of availability of reliable lab services. The problem was so severe that it is doubtful if the study would have had any success without the competent help of Dr. Zitko from DFO St. Andrews. Commercial labs were not readily available to do the fine analysis needed for a study of pollution and in several instances the accuracy of their analyses was questionable.

Recommendation: There should be national labs that are available to do this important work. These could either operate directly within a federal department such as the Research Station in St. Andrews or private labs could be certified for specific tests.

Problem 8: There were major problems discovered with most municipal sewage treatment facilities. For example, the Town of Newcastle has an approximate 40 to 50% bypass of its treatment plant.

Recommendation: Municipalities should not be allowed to expand beyond their capacity to treat the sewage that is generated. There are at least four government agencies involved with the regulation of sewage. The problem continues to worsen. There should only be one agency and it should be held accountable for results.

Problem 9: It was reported to the committee that septic haulers were dumping into storm sewers, the River and into local dumps. The report given to MREAC by the Department of Health and Community Services indicated that there had been no follow-up inspection for two years. Because of totally inadequate staffing, local inspection staff cannot possibly deal with the situation in any reasonable manner.

Recommendation: There has to be more attention paid to this problem. It would seem reasonable to request specific sectors of the public to report on any pollution infractions that are taking place. This would involve some co-ordination and training but would be well worth the effort. Again, it is critical that a system of reporting back to the original complainant be implemented, if the public is going to cooperate.

Problem 10: One of the potential problems identified early in this study was the possible change in flow patterns caused by forestry practices. The committee was pleased to note how much data was already available. Some stations have been monitored on a continuous basis since 1951. In spite of this, however, the committee was not given a satisfactory answer to the original question even though several requests were made and answers given.

Recommendation: It is critical that all government departments have staff in place on the river with an extensive local knowledge so that any research that is done makes use of this knowledge. It is a waste of time and money to answer questions that have already been answered correctly by the local people or, as happened in this case, give an answer that did not make sense when considering the geography of the area. Data was analyzed from flow rates low on the Main Southwest Miramichi where any effect would be minimal if it was detectable at all. The answer that was provided, eventually, in this case was given in such difficult language as to be of little use to the committee. Government agencies should use language that is easily understood by the public and should eschew obfuscation!

Problem 11: IT IS IMPOSSIBLE FOR THE AVERAGE PERSON TO KEEP TRACK OF ALL THE DEPARTMENTS AND AGENCIES THAT DEAL WITH POLLUTION ON THE RIVER.

Recommendation: Have ONE advertised contact point available to all. The responses and actions of government to these concerns should be constantly reported to an involved public.

NOTE: MREAC COULD PLAY A SIGNIFICANT, IMPORTANT, AND USEFUL ROLE IN THIS.

CHAPTER 10

PROPOSED GUIDELINES FOR MREAC

It is clear to the Committee that although the initial study is now complete, there remain many questions related to the health of the Miramichi River System. It is also clear that although many conclusions have resulted in even more recommendations, without some active monitoring these could easily become forgotten while the Report gathers dust on a shelf. The Committee feels the need to stay in place, as it is, long enough to develop a sound working plan and organizational structure that will maintain the necessary surveillance of the Miramichi and make sure that what should be done gets done. While this model structure is being developed, a number of Guidelines, both short term and long term, were discussed and agreed to at a regular meeting of MREAC on March 10, 1992. These are listed below to provide assurance to the public that their "watchdog" is still alive and well.

Short Term Recommendations:

1. The present committee stay in place until the recommendations contained in the report are dealt with. It is expected that the size of the committee would stay in excess of twenty-five with ongoing vacancies for representatives of interested groups and for interested individuals to fill.

2. The committee should portion out responsibility for dealing with specific recommendations to the appropriate agencies.

3. The committee will meet quarterly after the final report is published.

4. The TAG will still be a part of the committee but will act more in a consultative role than in their past work role for the committee.

5. The committee's role will also change to more resemble a board of directors.

6. The committee will establish time lines for each recommendation and will monitor progress in meeting these times.

7. The committee will act as a clearing house for future studies on the river.

8. The present phone will be maintained to facilitate quick action on any reported problems and to collect any concerns.

9. The committee will hire a part-time manager to coordinate the work of the committee between meetings.

10. The committee will convene an annual meeting to coordinate the activities of all agencies planning to do work on the river during the coming year.

11. After the release of the final report all committee meetings will be

fully open to the public.

12. The committee may wish to recommend studies that should be carried out on the river.

Long Term Recommendations

1. The committee will look at the long term development along the Miramichi.

2. The structure of the committee needs to be examined.

3. Shoreline use needs to be looked at. The impact of cottages, camps, camping, and shoreline house development needs to be carefully studied.

4. The relationship between air quality and water needs to be studied.

Financial

It was agreed that we should maintain our financial independence by encouraging continued support from participating organizations as well as seeking support from government programs.

MREAC MEMBERSHIP (Present and Past)

Vernon Goodfellow (Chairman)	Northumberland Salmon Protection Ass.
Vince McCarthy (vice-Chairman)	Mayor, Nelson-Miramichi
Harold Parlee (Treasurer)	Nordin
Tom Greathouse (Secretary)	Citizen, Newcastle
Charles Allan MD	Medical Doctor, Newcastle
Joyce Allan	Citizen, Newcastle
Mark Allen	Health and Community Services, Fredericton
David Assaff MD	Dept. Health and Community Services
Michael Augustine	Red Bank Indian Band
Ben Baldwin	Miramichi Environmental Society
Rupert Bernard	Mayor, Town of Chatham
Neil Brodie	NB Environment
John Brown	Citizen, Chatham
Jennie Bryenton	Greater Miramichi Chamber of Commerce
Michael Burt	University of New Brunswick
Dennis Daigle	N.B. Department of Environment, Chatham
Bernie Dube	NB Natural Resources & Energy
Edmond Drysdale	Maritime Fishermen's Union
Claude Ferron	Heath Steele Mines
Ted Frank	Miramichi Environmental Protection Ass.
John Legault	Dept. of Fisheries & Oceans-Gulf Region
George Lindsay	Environment Canada
John MacDougall	Miramichi Pulp & Paper Inc.
David MacLeod	Ultramar Canada
Timothy McCarthy	President, NB Labour Council
Vicki Oland Mills	Miramichi Salmon Association
Peter Murphy	Mayor, Newcastle
Joe O'Neill	Miramichi Pulp and Paper Inc.
Gilbert Savoie	Northumberland Woodlot Association
Michael Sprague	NB Environment
Harry Walker	Naturalist, Newcastle
Roy Walsh	Greater Miramichi Chamber of Commerce
Bruce Whipple	Northumberland Salmon Protection Association
Harry Williston	Miramichi Commercial Fishermen
Jerry Wilson, MD	Nordin
Vlado Zitko	Dept. of Fisheries and Oceans-St. Andrews

Alternates:

Zoel Breau	Maritime Fishermen's Union
Ernest Ferguson	Dept. of Fisheries & Oceans
Roy Parker	Environment Canada

Project Coordinator:

Jack Hunter	Sunny Corner

Technical Advisory Group:

Neil Brodie	NB Environment
Michael Burt	University of New Brunswick
John Legault	Dept. of Fisheries and Oceans
George Lindsay	Environment Canada
Michael Sprague	NB Environment
Vlado Zitko	Dept. of Fisheries and Oceans

ACKNOWLEDGEMENTS

As can be seen from the list of members of the Miramichi River Environmental Assessment Committee on the previous page, they represent diverse backgrounds but are all interested in and dedicated to environmental conservation of the Miramichi River.

It is with pleasure that I sit down to write a few inadequate words of appreciation to those who in some way made this mammoth undertaking go forward.

This was no small project. I was personally skeptical that anything so ambitious, so all-incompassing, could be accomplished in any reasonable time frame. I was especially skeptical because of the number of government departments involved.

This would not have happened without a great deal of unselfish effort on the part of a lot of people. I will not attempt to be exhaustive but will single out some of the key players.

First, I want to thank Ben Baldwin and the Miramichi Environmental Society for raising the public consciousness level about the Miramichi environment in general, and for also pushing government to get involved. Even though Mr. Baldwin later felt obligated to remove himself from this process, his contribution as an agitator is appreciated. It was his relentless questioning, probing, and demanding of answers that helped bring this committee together.

The Provincial Department of the Environment, as a department, has been critical to the success of this endeavor. In particular, Mr. Neil Brodie has been the key to this process. It has been his dedication, his weekends of work, his organization of manpower, and his patience that carried the rest of us through this process. It is important that those who read this report understand that much, if not most, of the untold hours of work put in by Mr. Brodie and others in the provincial Department of the Environment were put in during their own time.

In particular, I want to also thank the provincial Department of the Environment for requiring Repap Enterprises Ltd. to hold public meetings as a condition of their license to construct the A-2 paper machine. This requirement was added when it was realized that Repap did not have the proper environmental impact assessment for the construction of A-2.

Because of this, another key individual was added to this process - Mr. Joe O'Neill. Joe has worked hard to marshall support for this process both inside and outside of the Repap organization. He also played a key role in securing funding, especially from Repap, but also from other forest-based operations on the Miramichi. As well, Mr. O'Neill modelled precisely the appropriate role for industry in these sorts of processes. He stood ready to accept scientifically-based criticism of Repap provided it was scientically

based and provided it was fairly presented with criticism of all other industries and individuals affecting Miramichi waters.

It was our good fortune to obtain the services of an immensely-talented individual for our project coordination. This individual worked tirelessly for a nominal fee to keep this project going. Mr. Jack Hunter tackled this project with enthusiasm, with humor, with patience, with incredible organizational skills, and with persistence. It was a pleasure getting to know and work with him.

Dr. Vlado Zitko of the Department of Fisheries and Oceans (St. Andrews) was another person critical to this endeavour. He provided the unquestionable scientific depth to deal with the myriad of complex scientific issues raised during this study. He provided invaluable advice on how we should proceed to get good scientific data as well as providing the necessary checks to make sure that all testing done was up to standard.

There are many, many more who should be mentioned but I will mention only those who served on the "TAG" (Technical Advisory Group). They formed the backbone of the committee's work making recommendations and wrestling with the many coordination, scientific and technical problems facing us. In addition to Dr. Zitko, Jack Hunter, and Neil Brodie (previously mentioned), George Lindsay from the federal Department of the Environment was always present to assist both at TAG and at the committee meetings. His quiet, agreeable support was always there.

In addition, Mike Sprague from the Provincial Department of the Environment and John Legault from the Department of Fisheries and Oceans also freed considerable time to help with both TAG and the committee.

Dr. Burt, Professor and Past Chairman of the Department of Biology at U.N.B., who was retained by the committee to write the final report has also lent valuable services to both the TAG group and the committee during this past year.

Finally, the committee itself, which wrestled with the many scientific, political, financial, and organizational issues involved deserves a well-earned "thank-you". All committee members are leaders and are people who have busy schedules but yet gave of their time to make this happen. Thank you.

* * * * * *

GLOSSARY OF TERMS

assimilative capacity	the ability of a water system to absorb incoming stresses (waste) from natural or man-made sources and still maintain a healthy population of biota
base metals	refers to a group of metals commercially mined and includes such as zinc, copper and lead
benthic invertebrates	bottom dwelling creatures in fresh or salt water which are relatively immobile and have no backbone such as worms and larvae of flies
biota	any living organism; man, fish, bugs
buffered	well buffered water contains sufficient natural minerals to prevent pH changes due to acid rain or other natural acid sources
dissolved organic carbon (DOC)	a way of measuring the organic material in a water sample. The DOC will be from decaying material and a measure of the loading on the water system
dissolved oxygen	fish and other aquatic species extract oxygen which is dissolved in the water to live. Levels range from 0 to 12 mg/l or parts per million depending on temperature and what else is in the water and being eaten by bacteria. The bacterial processes use oxygen in competition with the fish
estuarine	section of a water body which is between the definitely freshwater and definitely saltwater environments. These areas are highly productive biologically and very important to many species.
fecael coliforms	Actually fecael coliform bacteria. An easy test used to indicate the possible presence of disease causing bacteria or viruses because they are excreted in the feces of warm blooded animals. They do not cause disease themselves.
hardness	Hard water is high in calcium and magnesium content. Groundwater is harder than surface water.
heavy metals	chemically similar family of metals e.g. arsenic, copper, cadmium, chromium, lead, mercury, nickel and zinc
inorganic chemicals	a group of chemicals not having a carbon based structure such as minerals or water

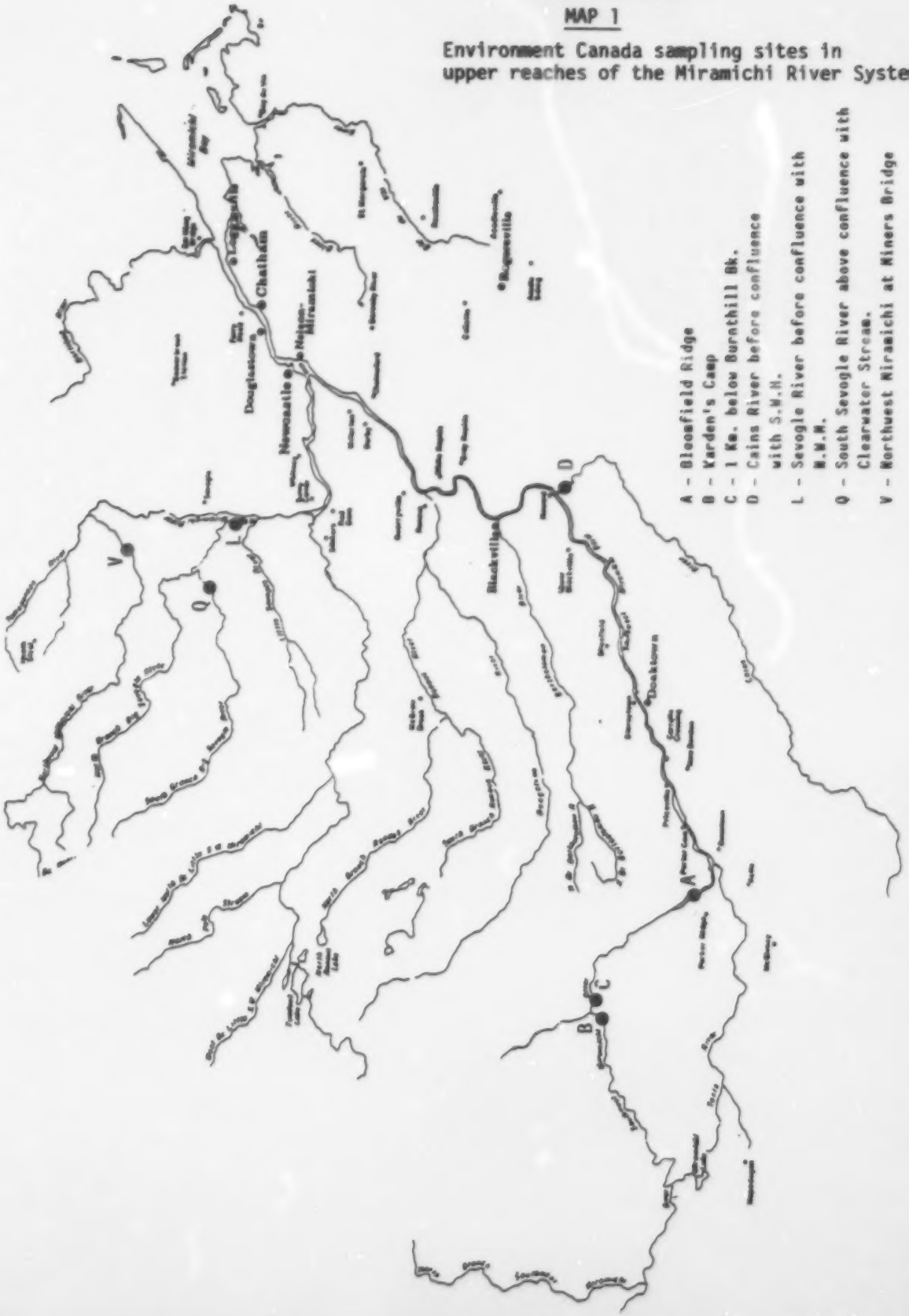
nitrogen	a nutrient which is necessary for growth of green plant material such as grasses on land or alge in water
non-point source	a source of pollutants which originates from a diverse area such as fertilizer runoff from a farming district
nutrient	a chemical which contributes to the growth of an organism but usually refers to phosphorus and nitrogen based chemicals
organic loading	the amount of organic material (uses oxygen when it decays) from natural or man-made sources being put into a watercourse
organic chemicals	a group of chemicals having a carbon based structure. Living things, residues of living things such as petroleum and man made chemicals based on a carbon structure
PAH	short form for polynuclear aromatic hydrocarbons (a family of chemicals). Naturally occurring in coal and oil. An organic chemical. Used as a pesticide for coating wood in the form of creosote
parameter	scientific name for tests to be done; example chloride and temperature are two parameters that could be done in a water quality investigation
PCB	short form for polychlorinated biphenyls (a family of chemicals). Not naturally occurring. Used in electrical equipment for insulating and fire resistant properties
PCP	short form for pentachlorophenol. Not naturally occurring. Used as a pesticide for coating wood. example: Pentox
pH	a numerical measure of the acid or alkali content of water with a scale of 0 (most acid) to 14 (most alkali). Most water is near neutral (7.0). pH=6.0 is 10 times more acid than 7.0 pH=5.0 is 100 times more acid than 7.0.
phosphorus	a nutrient which is necessary for growth of green plant material such as grasses on land or alge in water
point source	a source of pollutants which originates from a fixed point such as a pipe or ditch

pristine environment	an environment not impacted by man or natural disasters
sedimentation	the process of silt and other fine materials settling out in streams, rivers and lakes in quiet areas
soft	Soft water is low in calcium and magnesium content. Lake and river water is softer than groundwater
substrate geology	the rocks and minerals which surround the watercourse and contributed to the materials on the stream bottom
TKN	Total Kjeldahl Nitrogen. A measure of the nitrogen in a sample in all its forms ammonia, nitrates and organic nitrogen
tolerant species	species which can survive in more hostile environments such as low dissolved oxygen, abnormal pH, high temperature, etc
topography	the measure of the elevation of the land above sea level

MIRAMICHI RIVER ENVIRONMENTAL
ASSESSMENT COMMITTEE
(Miramichi Watershed)

MAP 1

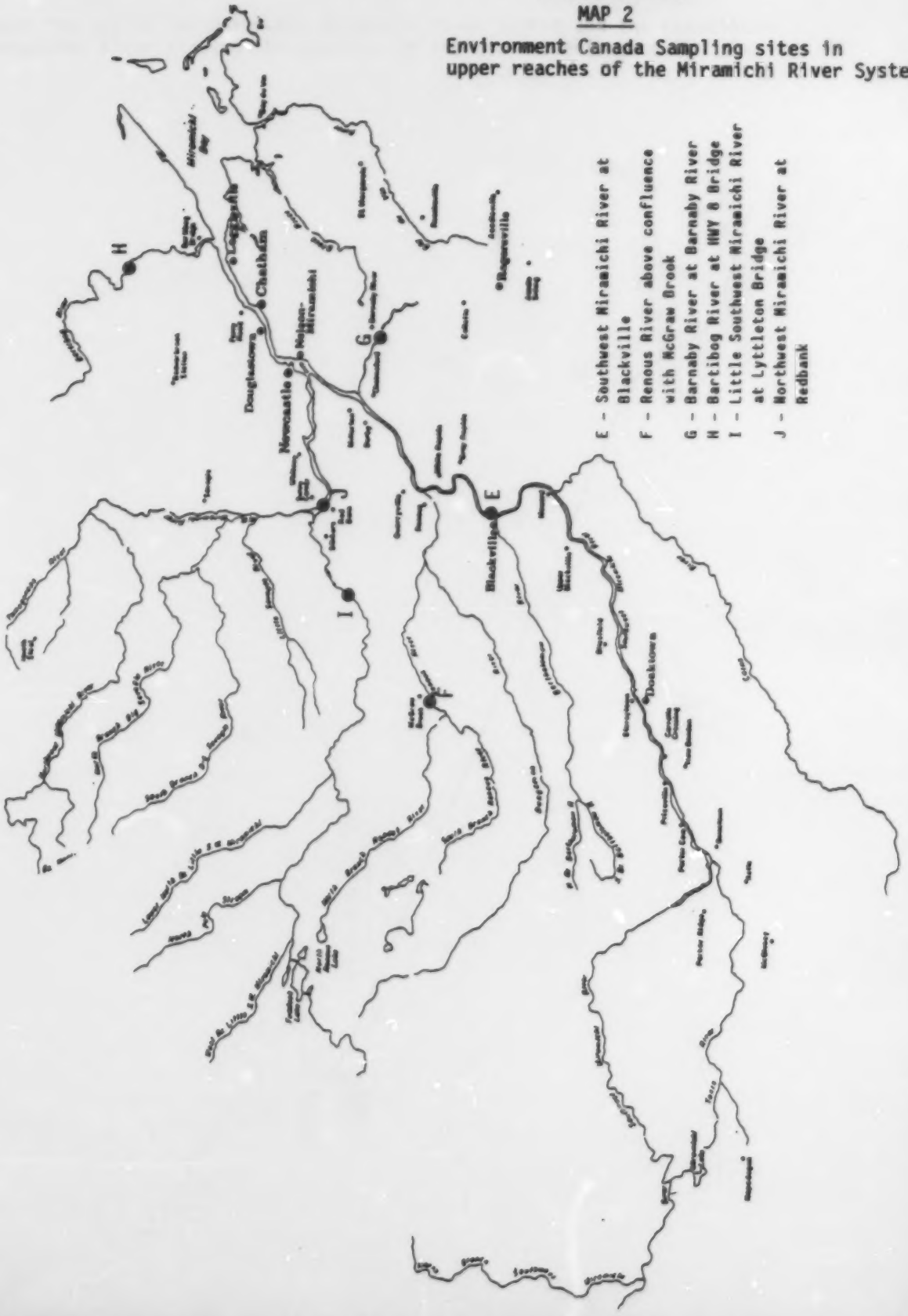
Environment Canada sampling sites in upper reaches of the Miramichi River System.


A - Bloomfield Ridge
B - Varden's Camp
C - 1 Km. below Burnthill Bk.
D - Cains River before confluence with S.W.M.
L - Sevogle River before confluence with N.W.M.
Q - South Sevogle River above confluence with Clearwater Stream.
V - Northwest Miramichi at Miners Bridge
Chatham
Newcastle
Douglastown
Blackville
Doaktown

MIRAMICHI RIVER ENVIRONMENTAL
ASSESSMENT COMMITTEE
(Miramichi Watershed)

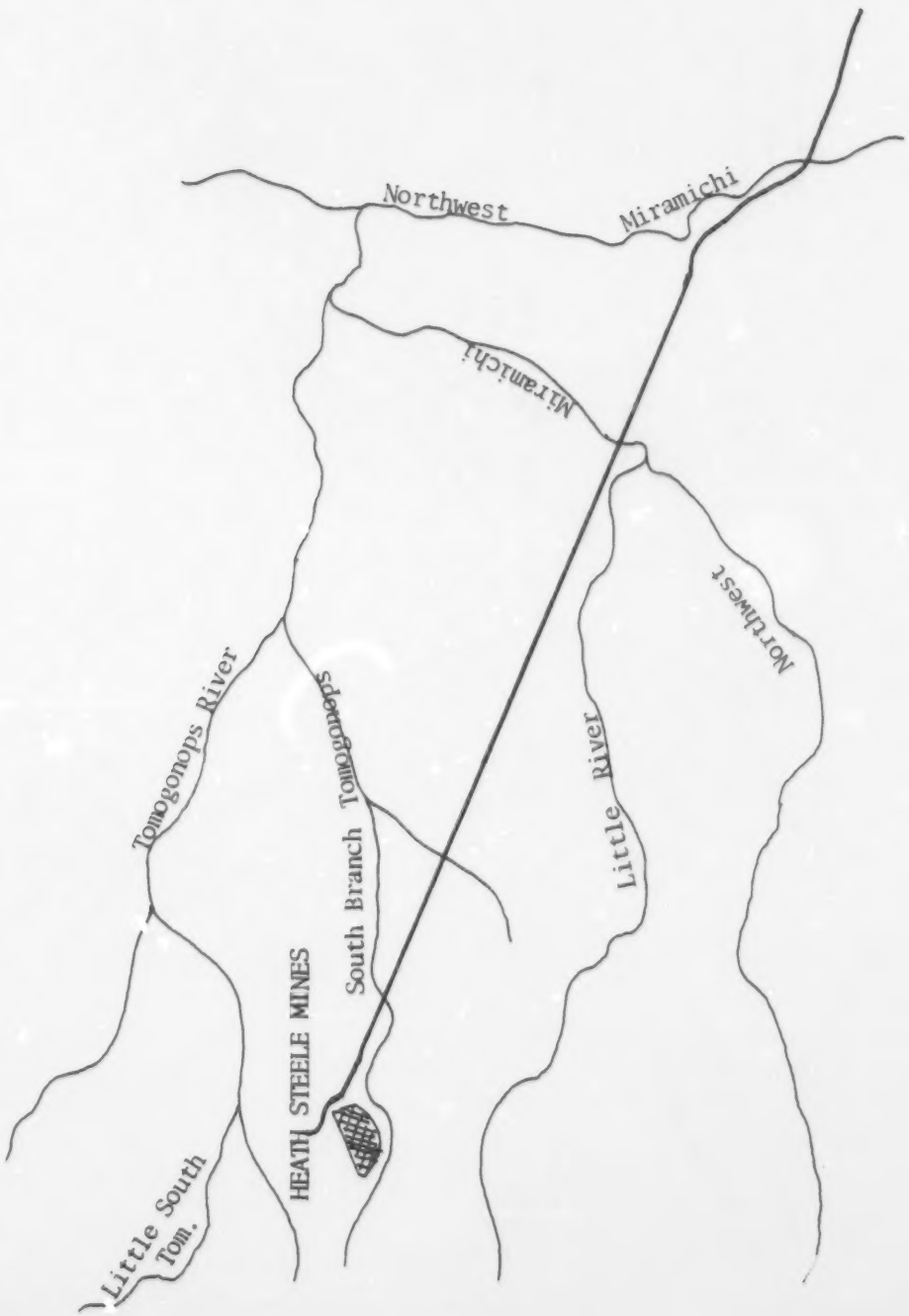
MAP 2

Environment Canada Sampling sites in upper reaches of the Miramichi River System.



MAP 3

Upper reaches of the Northwest Miramichi River System and the associated Tomogonops River showing the position of the Heath Steele Mine.



MAP 4

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE
(Miramichi Watershed)

MAP 5

Sampling sites P1, P2, P3, and P4 used in the Parker Study of the effect of mining pollution of the Tomogonops River by Heath Steele Mines Ltd.

MIRAMICHI RIVER ENVIRONMENTAL
ASSESSMENT COMMITTEE
(Miramichi Watershed)

MAP 6

Sites sampled for benthic invertebrates in the Miramichi River System (See Table IV)

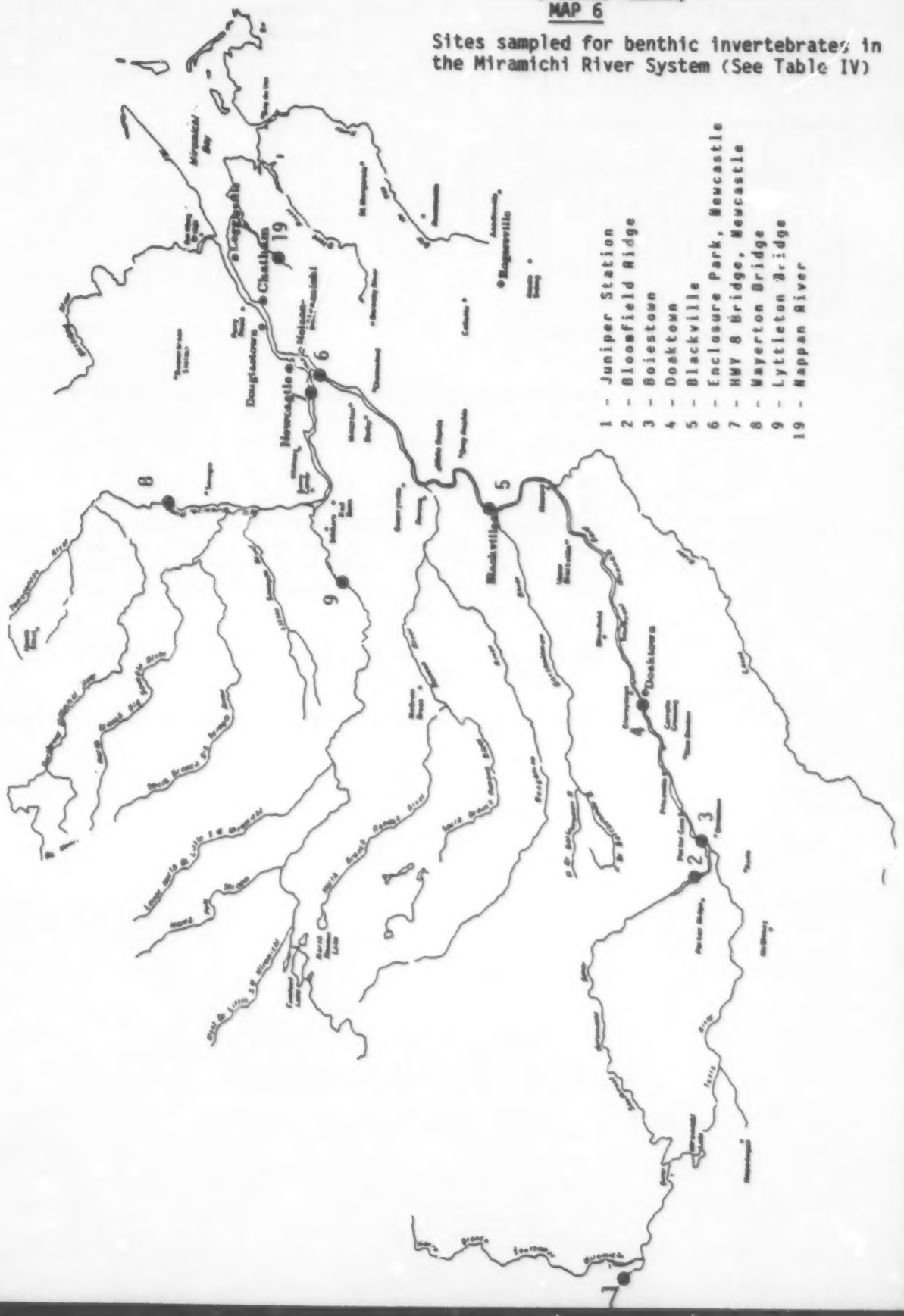


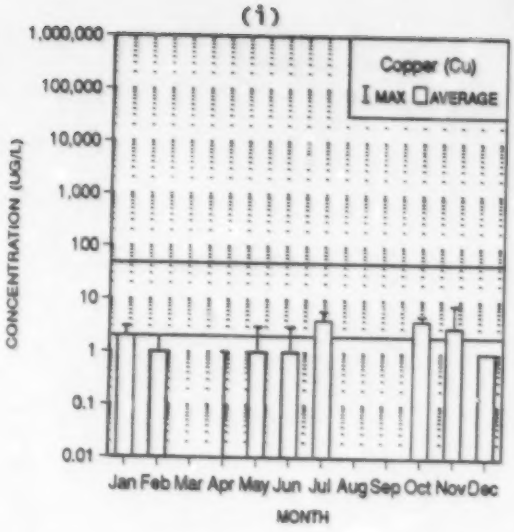
Figure 1. Monthly averages for copper and zinc concentrations in the Northwest Miramichi, at Miner's Bridge on Highway 430, during 1963. (i) Copper; (ii) Zinc.

(**Note**: The horizontal lines at 2 µg/L (copper) and 30 µg/L (zinc) are the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the lines at 48 µg/L (copper) and 600 µg/L (zinc) are the lethal concentrations* above which juvenile Atlantic salmon will start to die within a day or two.)

[Graphs constructed from data provided by Sprague and Carson, 1964.]

*See Table I for various lethal concentration levels.

Figure 1


(i)
Copper (Cu)
I MAX ☐AVERAGE
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH

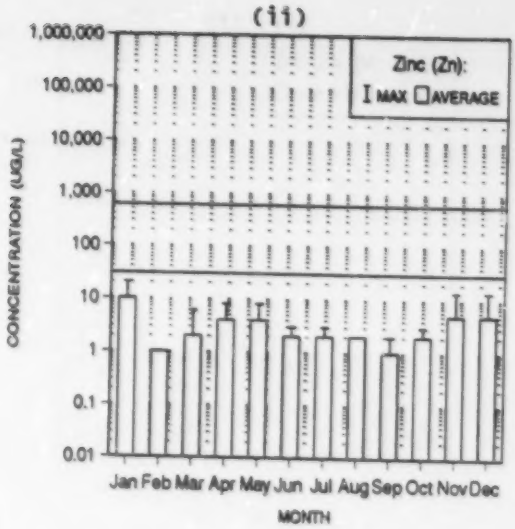
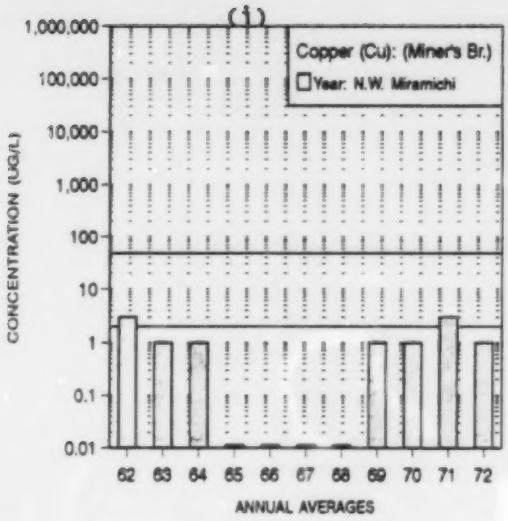

(ii)
Zinc (Zn):
I MAX ☐AVERAGE
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH

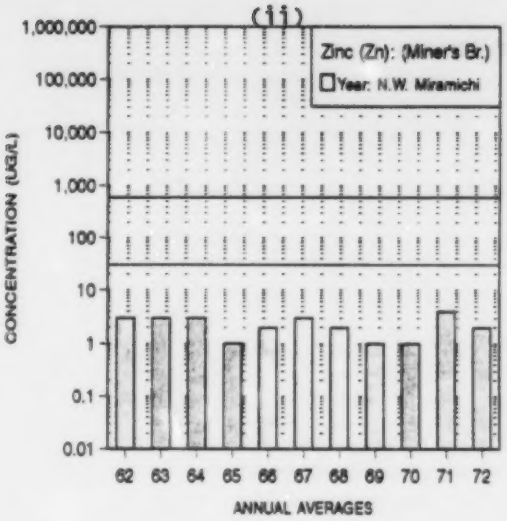
Figure 2. Annual averages for copper and zinc concentrations in the Northwest Miramichi, at Miner's Bridge on Highway 430, from 1962 to 1972, along with monthly averages for these metals at the same site in 1972. (i & iii)) Copper; (ii & iv) Zinc.

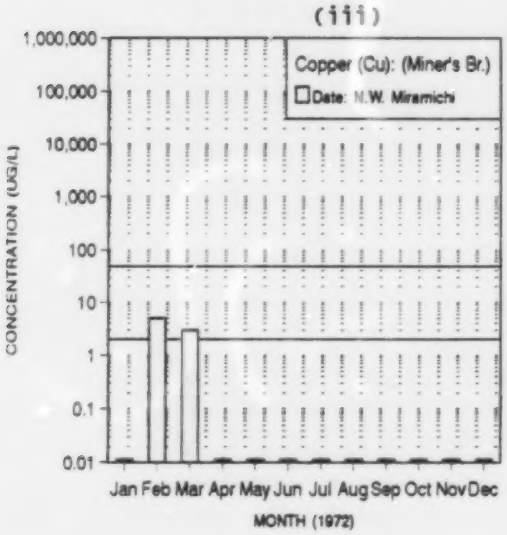
(**Note**: The horizontal lines at 2 μg/L (copper) and 30 μg/L (zinc) are the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the lines at 48 μg/L (copper) and 600 μg/L (zinc) are the lethal concentrations above which juvenile Atlantic salmon will start to die within a day or two.)

[Graphs constructed from data provided by Carson, 1973.]

Figure 2


(i)
Copper (Cu): (Miner's Br.)
Year: N.W. Miramichi
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
62 63 64 65 66 67 68 69 70 71 72
ANNUAL AVERAGES


(ii)
Zinc (Zn): (Miner's Br.)
Year: N.W. Miramichi
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
62 63 64 65 66 67 68 69 70 71 72
ANNUAL AVERAGES


(iii)
Copper (Cu): (Miner's Br.)
Date: N.W. Miramichi
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH (1972)

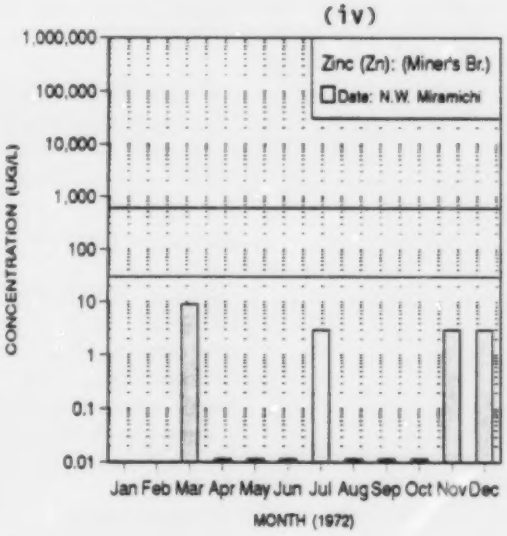

(iv)
Zinc (Zn): (Miner's Br.)
Date: N.W. Miramichi
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH (1972)

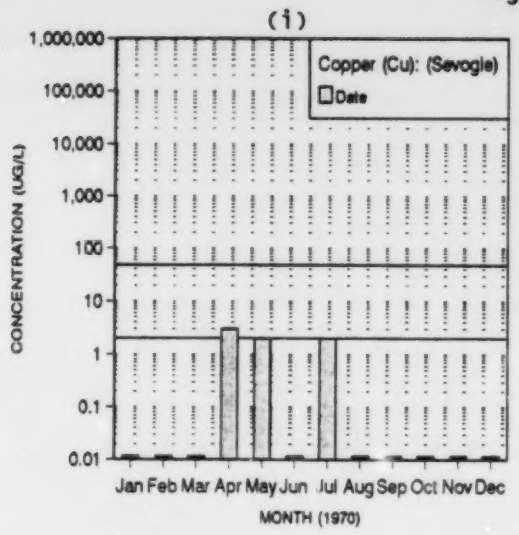
Figure 3. Monthly and annual averages for copper and zinc concentrations in the Sevogle River, just before it enters the Northwest Miramichi River.

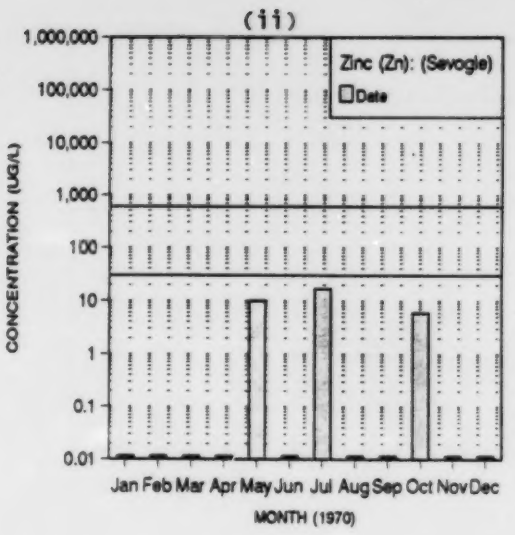
(i and iii) Monthly averages for copper in 1970 and 1972 respectively;
(ii and iii) Monthly averages for zinc in 1970 and 1972 respectively;
(v and vi) Annual averages from 1966 to 1972 for copper and zinc respectively.

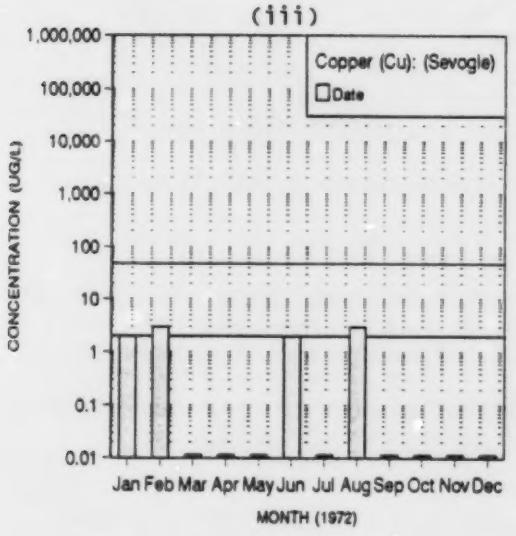
(**Note**: The horizontal lines at 2 μg/L (copper) and 30 μg/L (zinc) are the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the lines at 48 μg/L (copper) and 600 μg/L zinc are the lethal concentrations above which juvenile Atlantic salmon will start to die within a day or two.)

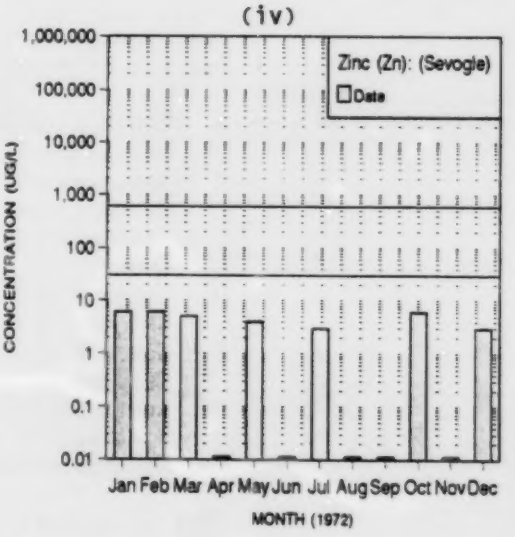
[Graphs constructed from data provided in Zitko and Carson, 1971 (Fig. 3.i and ii) and in Carson, 1973 (Fig. 3. iii-vi).]

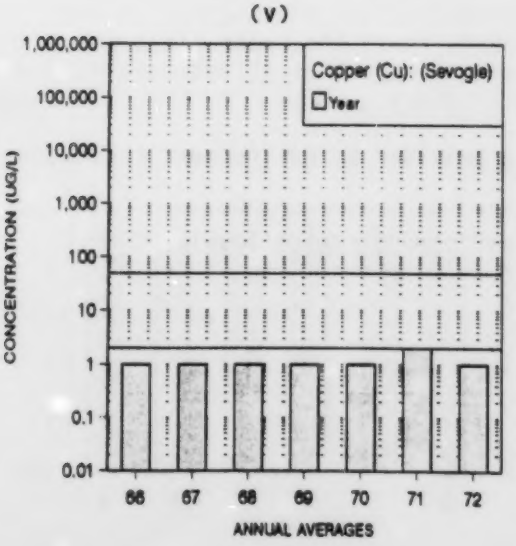
Figure 3


(i)
Copper (Cu): (Sevogle)
Date
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH (1970)


(ii)
Zinc (Zn): (Sevogle)
Date
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH (1970)


(iii)
Copper (Cu): (Sevogle)
Date
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH (1972)


(iv)
Zinc (Zn): (Sevogle)
Date
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH (1972)


(v)
Copper (Cu): (Sevogle)
Year
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
66 67 68 69 70 71 72
ANNUAL AVERAGES

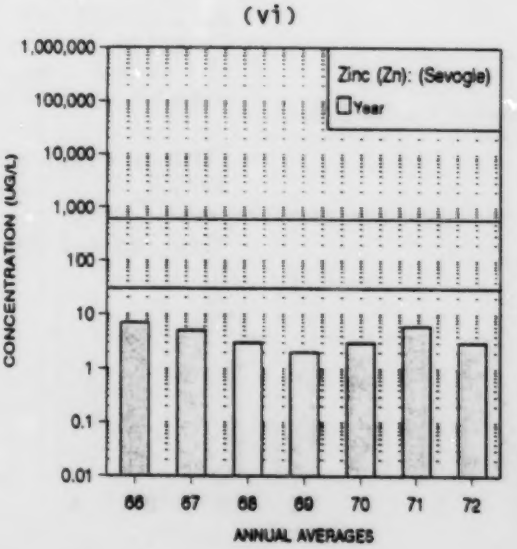

(vi)
Zinc (Zn): (Sevogle)
Year
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
66 67 68 69 70 71 72
ANNUAL AVERAGES

Figure 4. Average, median and maximum concentrations of : copper (i); zinc (ii); cadmium (iii); mercury (iv); iron (v); and lead (vi) recorded at various sites (see Map 1 and below) in the upper reaches of Miramichi River System between 1961 and 1977.

A - South Miramichi River at bridge, Bloomfield Ridge, Northumberland County.
B - Southwest Miramichi River 2.4 km above Burnthill Brook at wardens camp.
C - Southwest Miramichi River 1 km below Burnthill Brook, York County.
D - Cains river at confluence with Southwest Miramichi River at bridge.
L - Sevogle River at confluence with Northwest Miramichi River, Curventon.
Q - South Sevogle River above confluence with Clearwater Stream.
V - Northwest Miramichi River at Highway 430 Bridge, Northumberland County.

(**Note**: The horizontal lines at 2 µg/L (copper), 30 µg/L (zinc), 0.2 µg/L (cadmium), 0.1 µg/L (mercury), 300 mg/L (iron), and 1 µg/L (lead) are the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the upper lines represent the lethal concentrations above which either Atlantic salmon, or other tested fish species* will die.)

[Graphs constructed from data provided by Environment Canada, 1979.]

*See Table I for various lethal concentration levels.

Figure 4

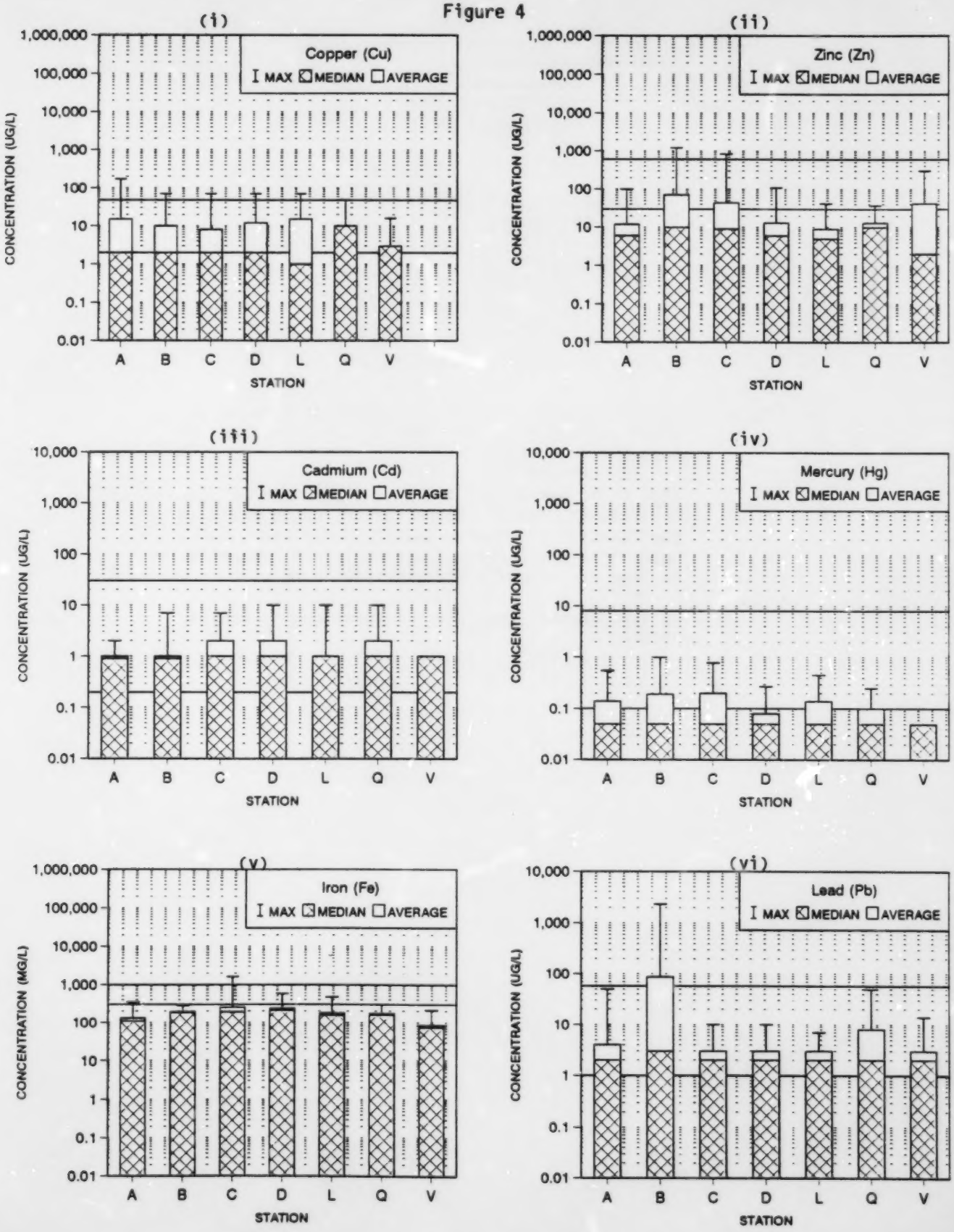

(i)
Copper (Cu)
I MAX ⊠MEDIAN □AVERAGE
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
A B C D L Q V
STATION
(ii)
Zinc (Zn)
I MAX ⊠MEDIAN □AVERAGE
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
A B C D L Q V
STATION
(iii)
Cadmium (Cd)
I MAX ⊠MEDIAN □AVERAGE
CONCENTRATION (UG/L)
10,000
1,000
100
10
1
0.1
0.01
A B C D L Q V
STATION
(iv)
Mercury (Hg)
I MAX ⊠MEDIAN □AVERAGE
CONCENTRATION (UG/L)
10,000
1,000
100
10
1
0.1
0.01
A B C D L Q V
STATION
(v)
Iron (Fe)
I MAX ⊠MEDIAN □AVERAGE
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
A B C D L Q V
STATION
(vi)
Lead (Pb)
I MAX ⊠MEDIAN □AVERAGE
CONCENTRATION (UG/L)
10,000
1,000
100
10
1
0.1
0.01
A B C D L Q V
STATION

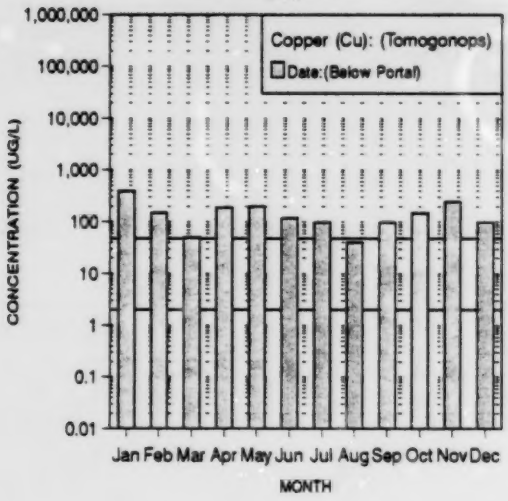
Figure 5. Monthly samples from the Little South Tomogonops River collected in 1972 showing concentrations of copper (i) and Zinc (ii).

(**Note**: The horizontal lines at 2 μg/L and 30 μg/L indicate the "safe" concentrations recommended in the Canadian Freshwater quality Guidelines, the upper horizontal lines show the lethal concentration for copper (48 μg/L) and zinc (600 μg/L).

[Graphs constructed from data provided in Carson, 1973.]

Figure 5

(i)


Copper (Cu): (Tomogonops)
Date:(Below Portal)
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH

(ii)

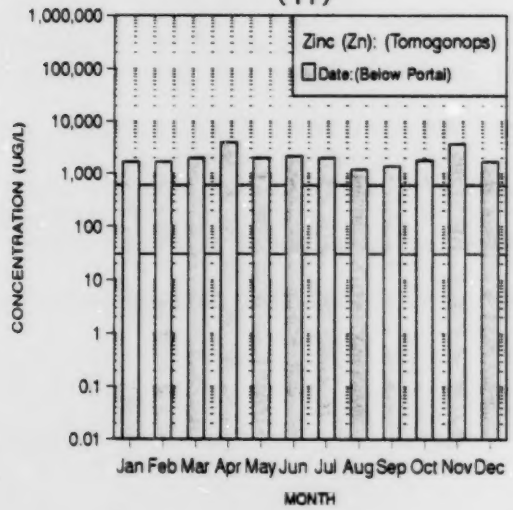
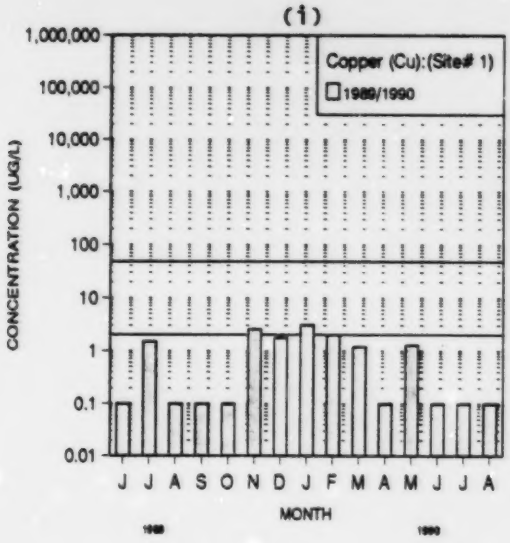

Zinc (Zn): (Tomogonops)
Date:(Below Portal)
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MONTH

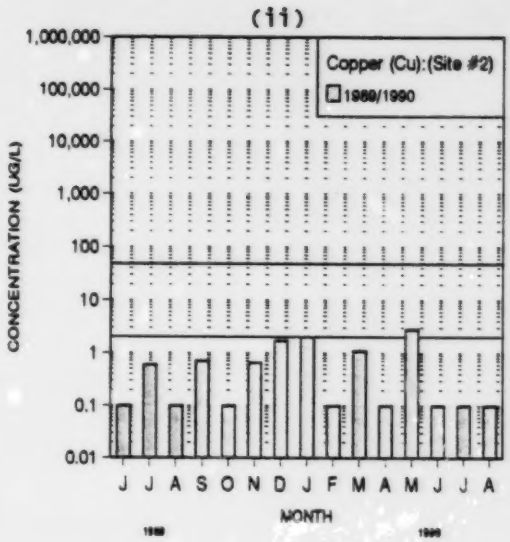
Figure 6. Concentrations of copper in monthly samples collected from Group I sites: (i) Juniper Station; (ii) Bloomfield Ridge; (iii) Juniper; (iv) Deersdale; (v) Cains River; (vi) Sevogle River; (vii) Burnthill Mine; and (viii) Taxis River.

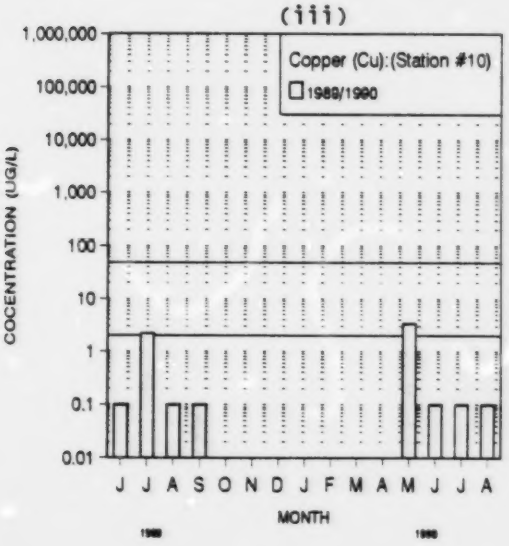
(**Note**: The horizontal line at 2 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 48 μg/L is the concentration above which young Atlantic salmon die.)

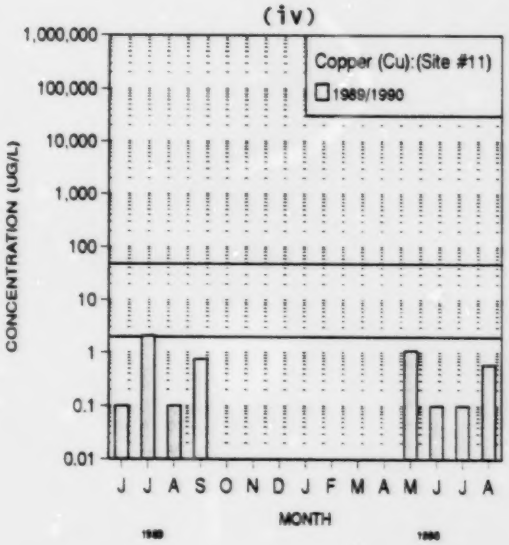
[Graph constructed from data collected by MREAC.]

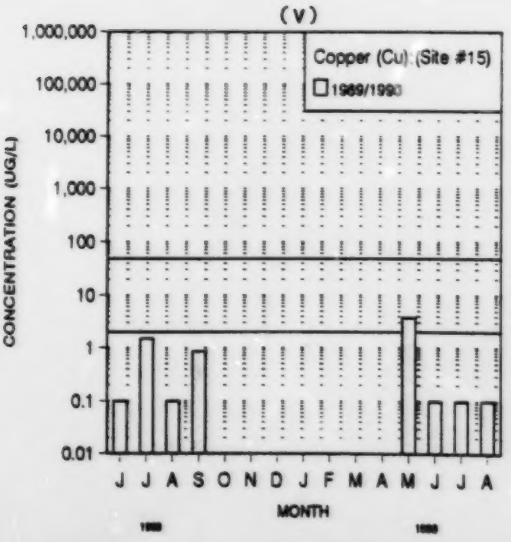
Figure 6


(i)
Copper (Cu):(Site# 1)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Copper (Cu):(Site #2)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iii)
Copper (Cu):(Station #10)
1989/1990
COCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Copper (Cu):(Site #11)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(v)
Copper (Cu): (Site #15)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

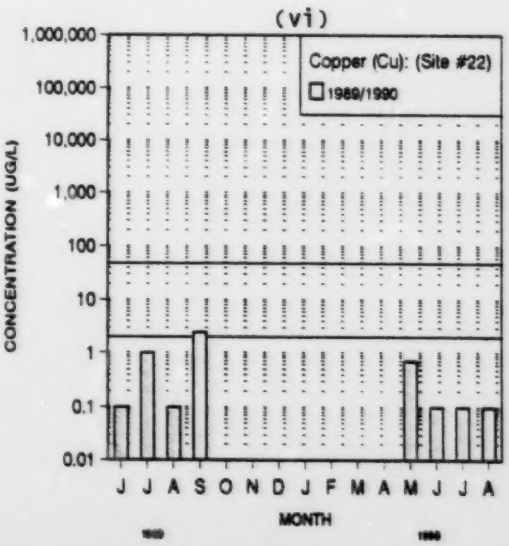
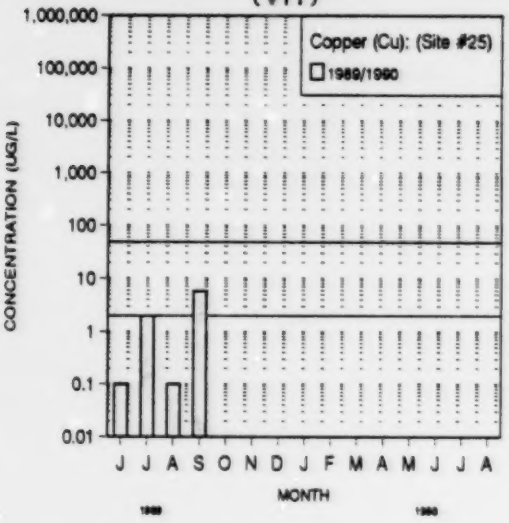

(vi)
Copper (Cu): (Site #22)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

Figure 6 con.

(vii)



(viii)

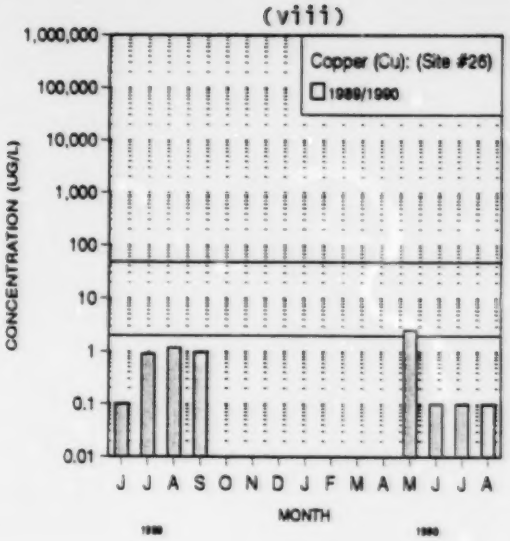
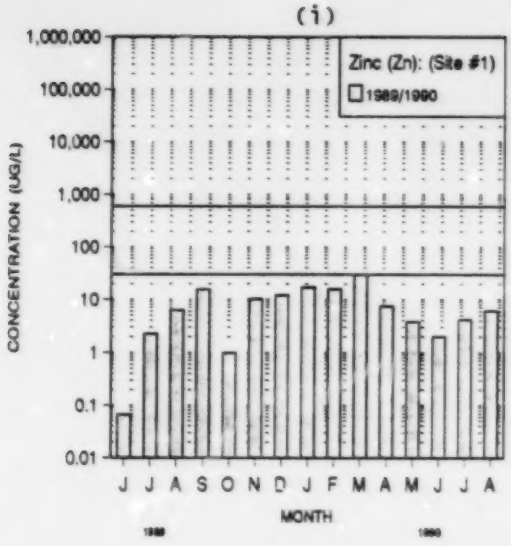
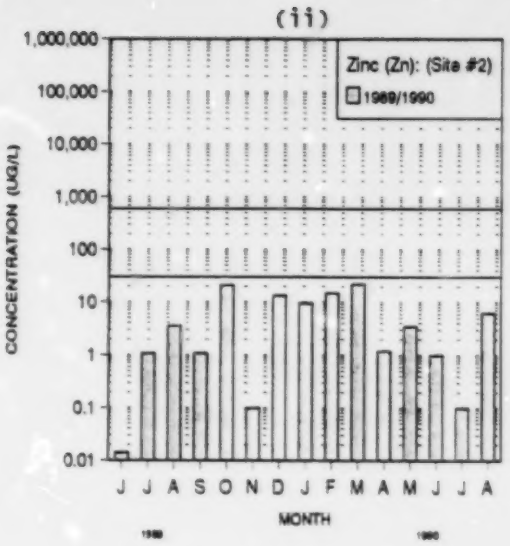


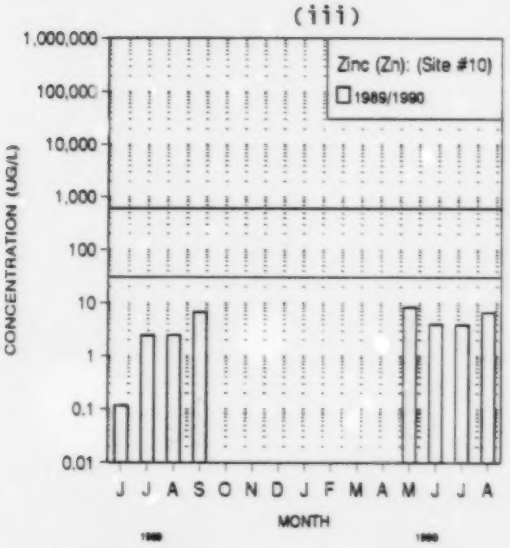
Figure 7. Concentrations of zinc in monthly samples collected from Group I sites: (i) Juniper Station; (ii) Bloomfield Ridge; (iii) Juniper; (iv) Deersdale; (v) Cains River; (vi) Sevogle River; (vii) Burnthill Mine; and (viii) Taxis River.

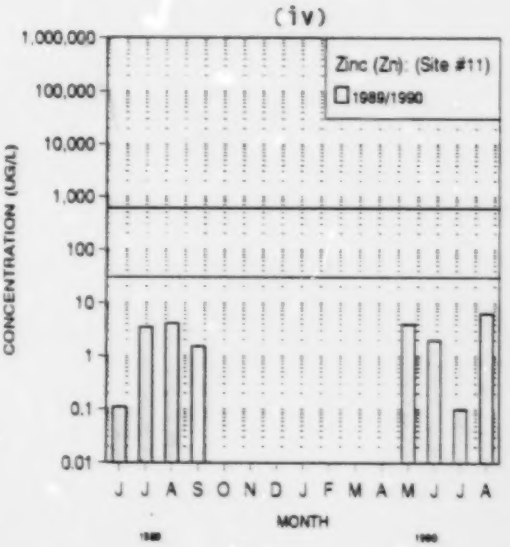
(**Note**: The horizontal line at 30 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines: the upper horizontal line at 600 μg/L is the concentration above which young Atlantic salmon die.)

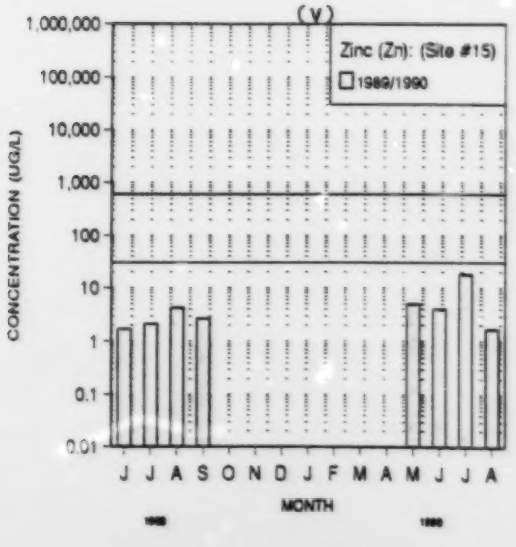
Figure 7


(i)
Zinc (Zn): (Site #1)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Zinc (Zn): (Site #2)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iii)
Zinc (Zn): (Site #10)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Zinc (Zn): (Site #11)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(v)
Zinc (Zn): (Site #15)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

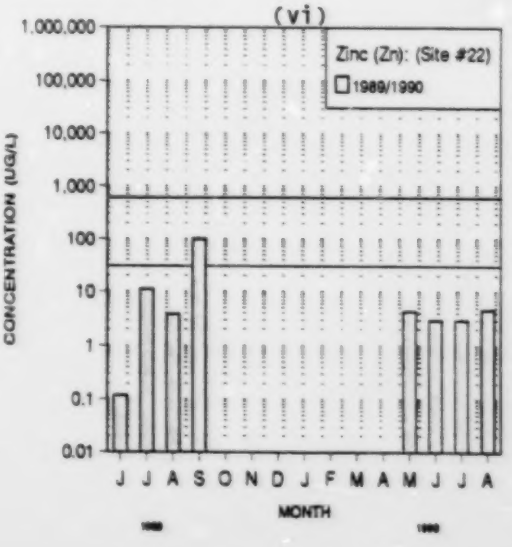
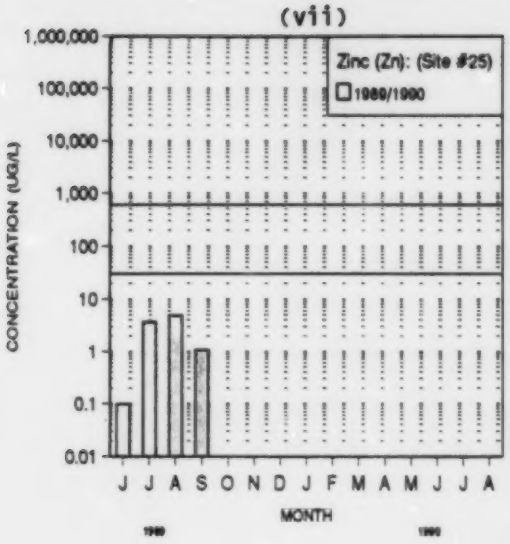

(vi)
Zinc (Zn): (Site #22)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

Figure 7 con.

(vii)



(viii)

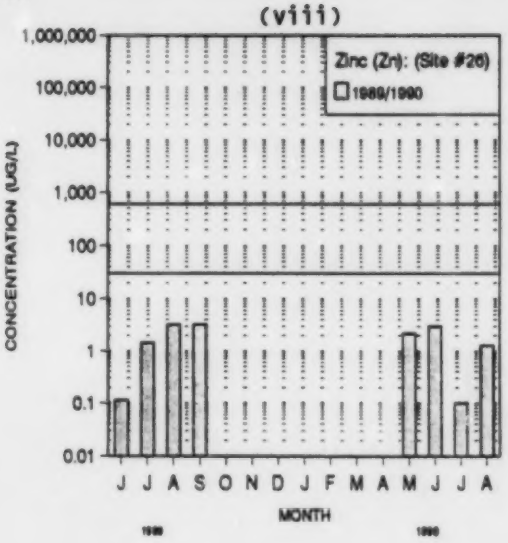
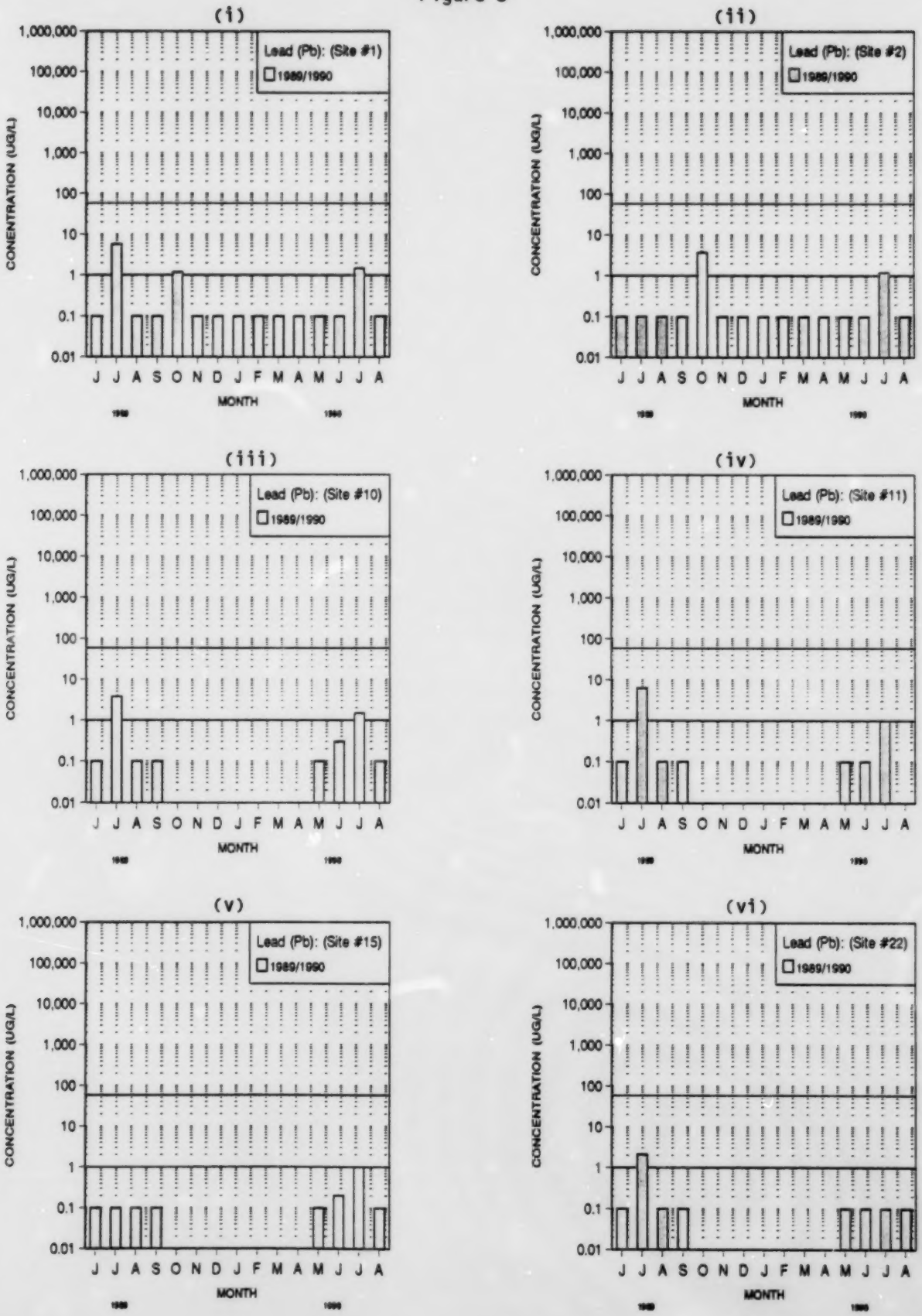


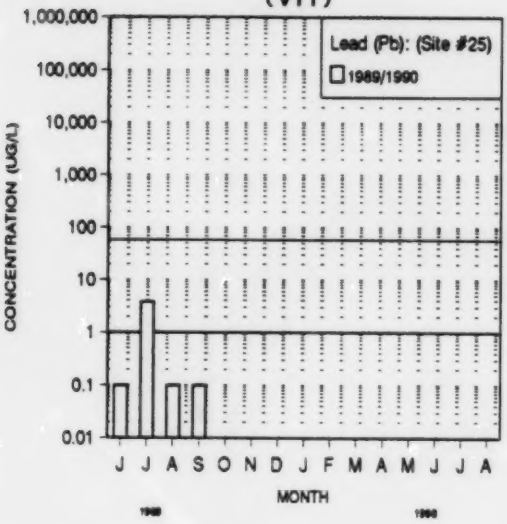
Figure 8. Concentrations of lead in monthly samples collected from Group I sites (i) Juniper Station; (ii) Bloomfield Ridge; (iii) Juniper; (iv) Deersdale; (v) Cains River; (vi) Sevogle River; (vii) Burnthill Mine; and (viii) Taxis River.

(**Note**: The horizontal line at 1 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 58 μg/L is the concentration above which young Atlantic salmon die.)

Figure 8


(i)
Lead (Pb): (Site #1)
1989/1990
(ii)
Lead (Pb): (Site #2)
1989/1990
(iii)
Lead (Pb): (Site #10)
1989/1990
(iv)
Lead (Pb): (Site #11)
1989/1990
(v)
Lead (Pb): (Site #15)
1989/1990
(vi)
Lead (Pb): (Site #22)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(vii)


Lead (Pb): (Site #25)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(viii)

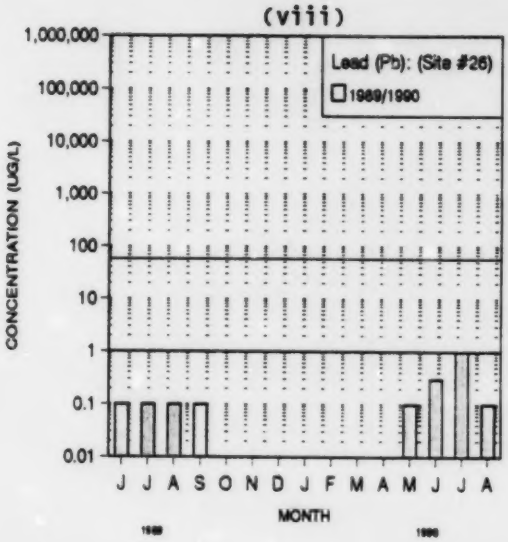
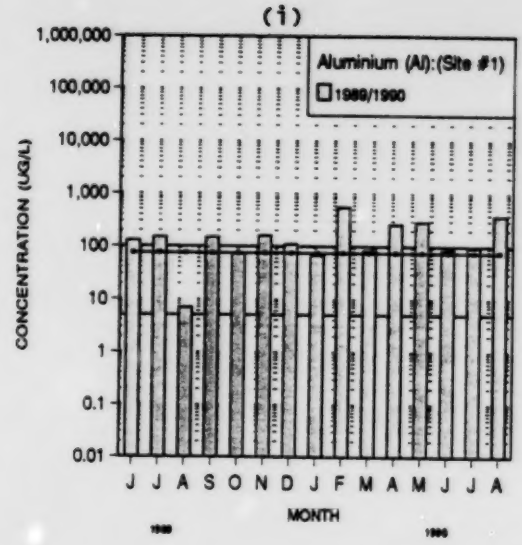

Lead (Pb): (Site #26)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

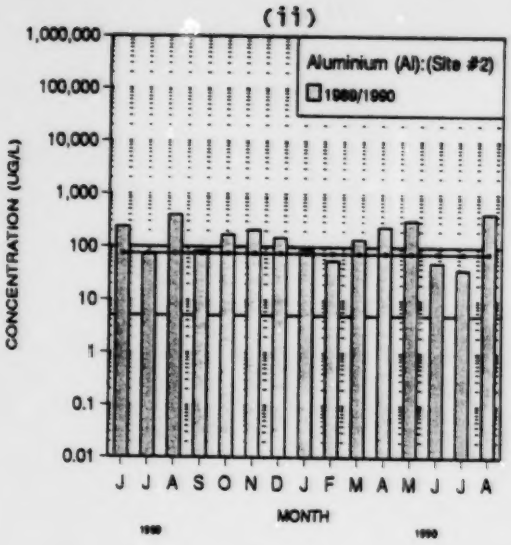
Figure 9. Concentrations of aluminum in monthly samples collected from Group I sites: (i) Juniper Station; (ii) Bloomfield Ridge; (iii) Juniper; (iv) Deersdale; (v) Cains River; (vi) Sevogle River; (vii) Burnthill Mine; and (viii) Taxis River.

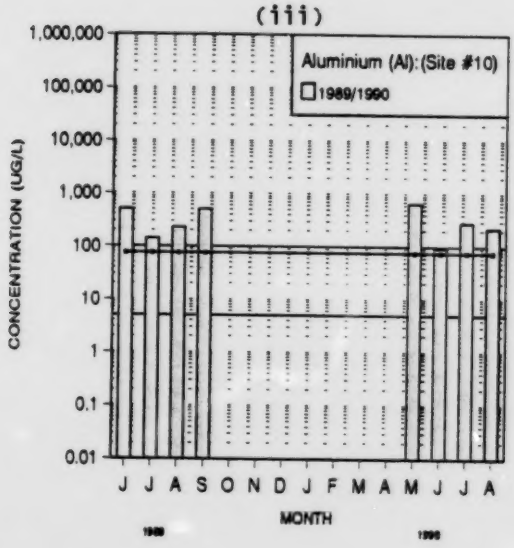
(**Note**: The horizontal lines at 5 μg/L and 100 μg/L indicate the "safe" concentrations recommended by the Canadian Freshwater Quality Guidelines for water with a pH less than 6.5 and over 6.5 respectively; the horizontal line at 75 μg/L is the concentration shown to be lethal to juvenile rainbow trout at a pH of less than 6.5.)

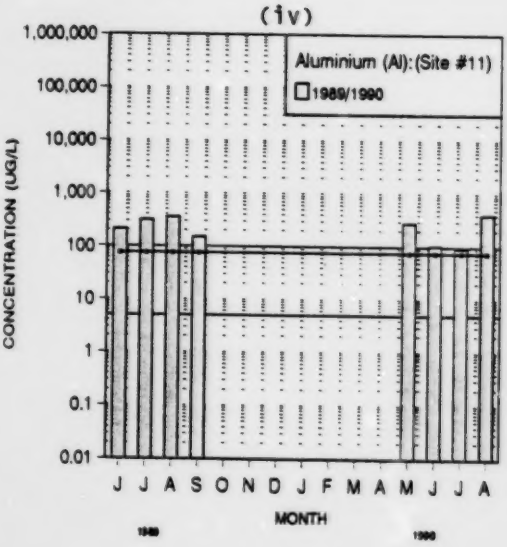
[Graphs constructed from data collected by MREAC.]

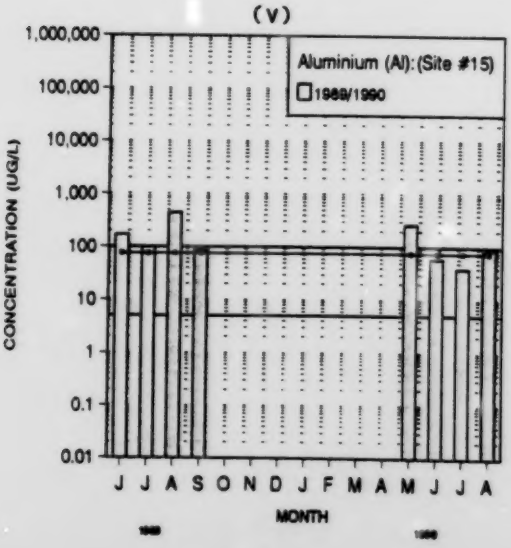
Figure 9

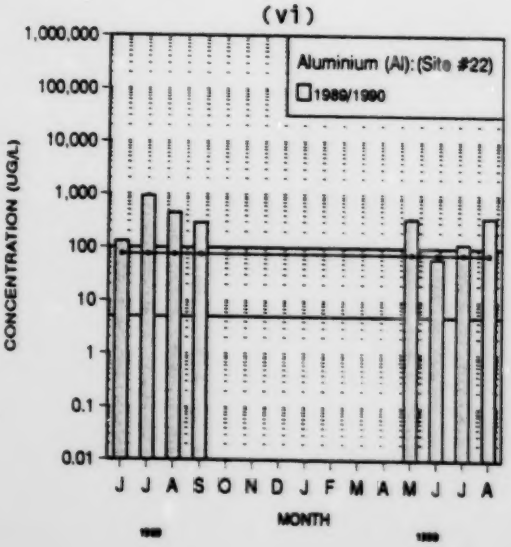

(i)
Aluminium (Al):(Site #1)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Aluminium (Al):(Site #2)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

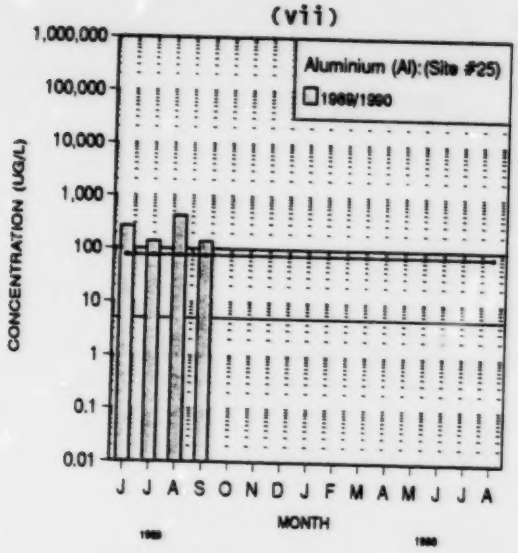

(iii)
Aluminium (Al):(Site #10)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Aluminium (Al):(Site #11)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(v)
Aluminium (Al):(Site #15)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(vi)
Aluminium (Al):(Site #22)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(vii)


Aluminium (Al): (Site #25)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(viii)

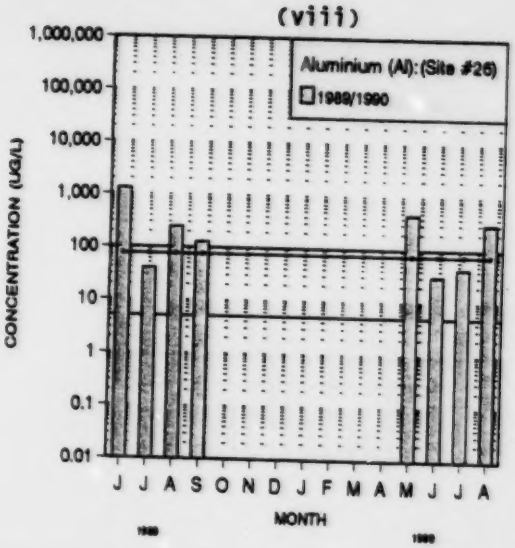
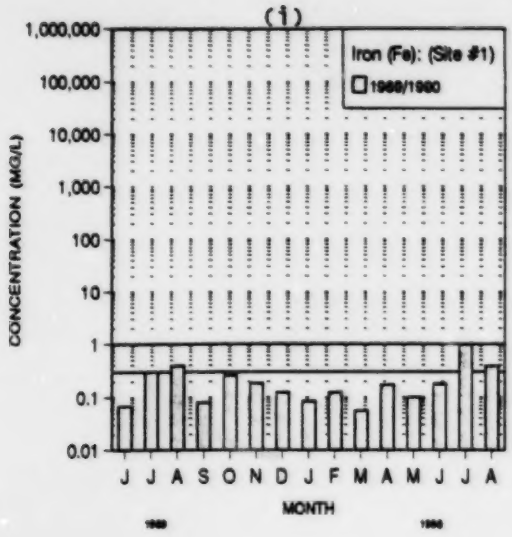
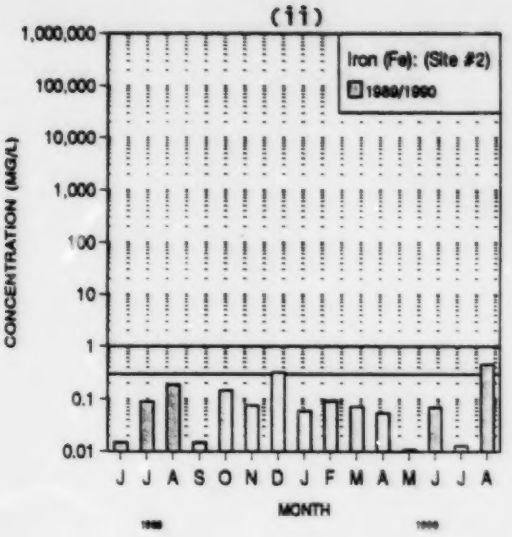

Aluminium (Al): (Site #26)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

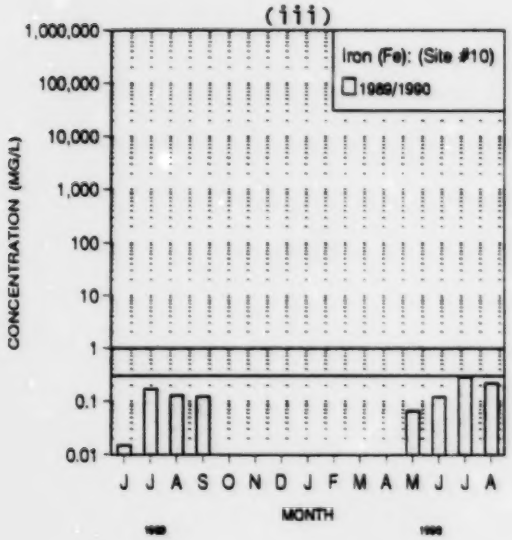
Figure 10. Concentrations of iron in monthly samples collected from Group I sites: (i) Juniper Station; (ii) Bloomfield ridge; (iii) Juniper; (iv) Deersdale; (v) Cains River; (vi) Sevogle River; (vii) Burnthill Mine; and (viii) Taxis River.

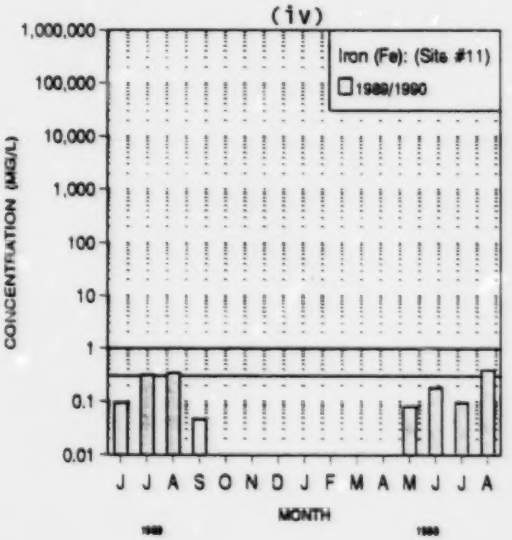
(**Note**: The horizontal lines at 0.3 mg/L indicate the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 1.0 mg/L indicates the level above which fish will start to die.

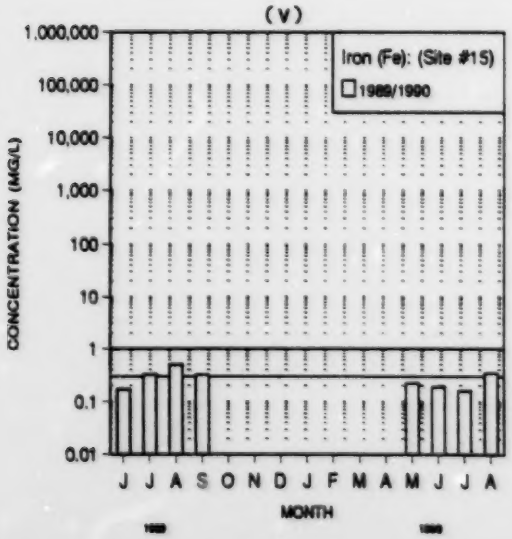
Figure 10

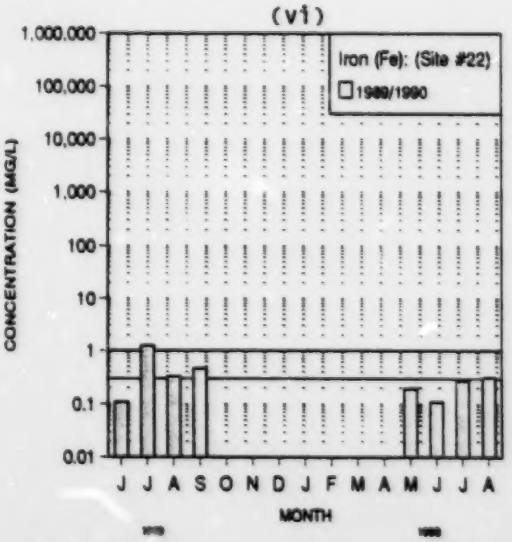

(i)
Iron (Fe): (Site #1)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Iron (Fe): (Site #2)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

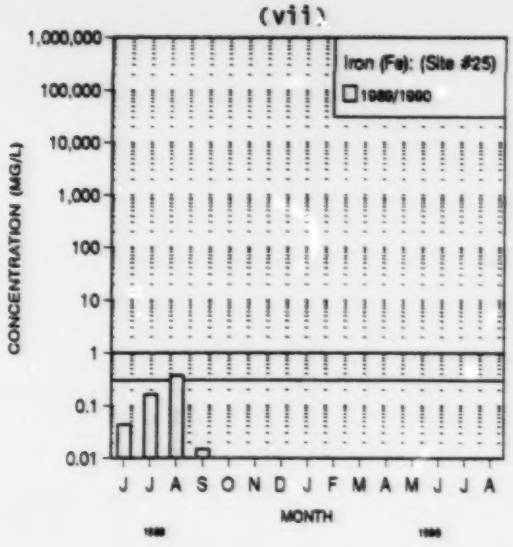

(iii)
Iron (Fe): (Site #10)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Iron (Fe): (Site #11)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(v)
Iron (Fe): (Site #15)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(vi)
Iron (Fe): (Site #22)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(vii)


Iron (Fe): (Site #25)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(viii)

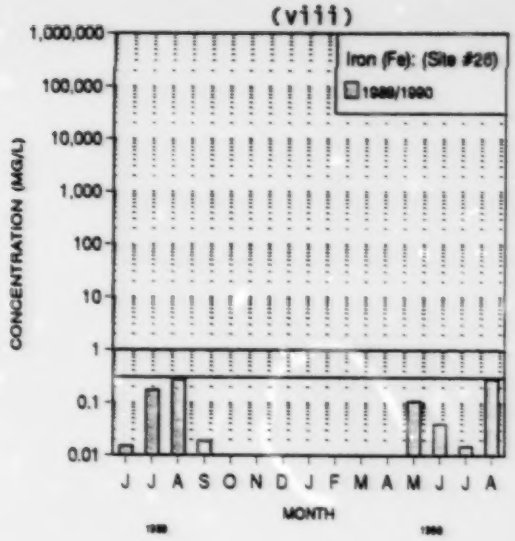
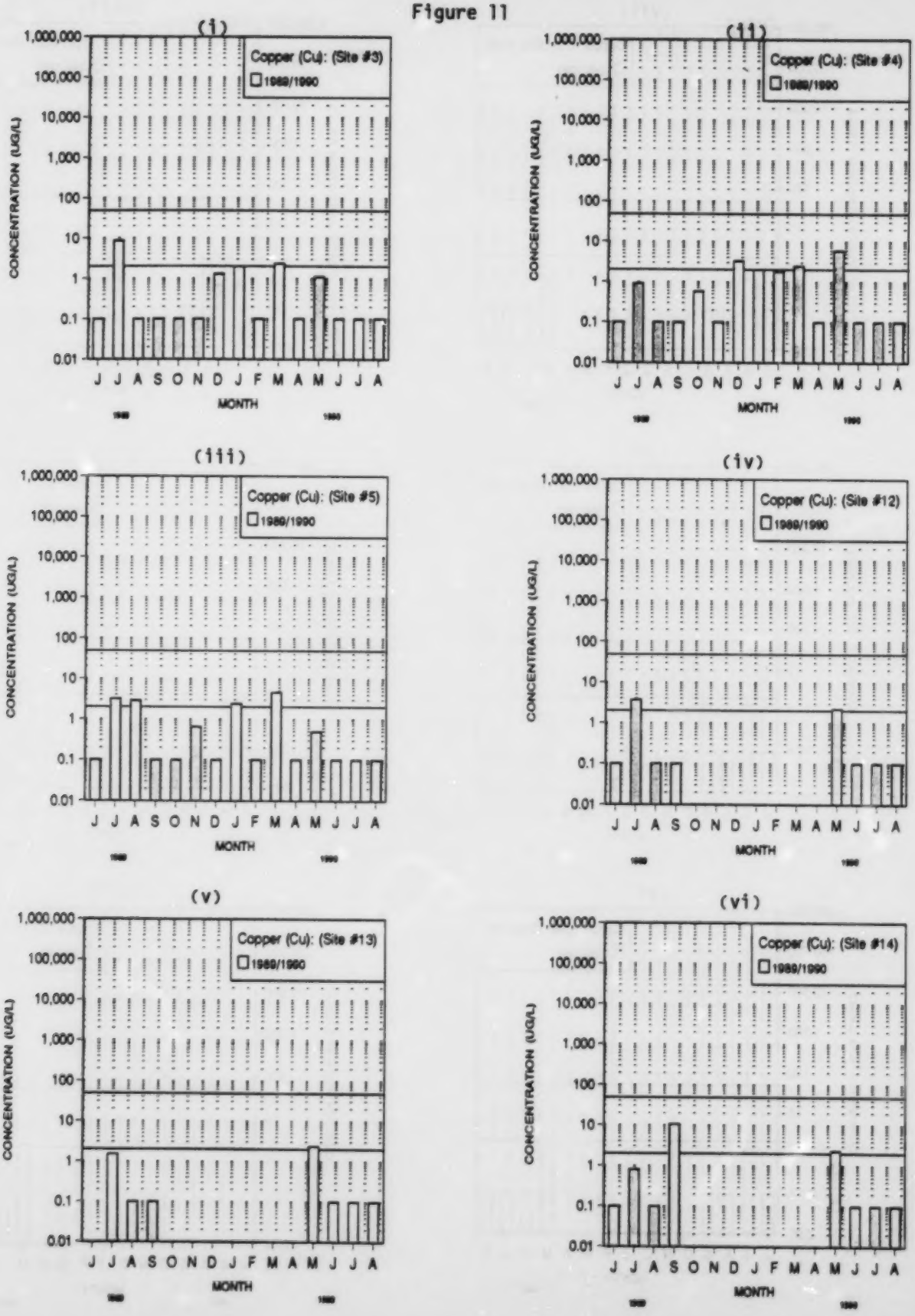

Iron (Fe): (Site #26)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

Figure 11. Concentrations of copper in monthly samples collected from Group IIa sites: (i) Boisetown; (ii) Doaktown Bridge; (iii) Blackville; (iv) Ludlow; (v) Nelson's Hollow; (vi) Upper Blackville; (vii) Batholomew River; (viii) Quarryville; (ix) Barnaby River; (x) Renous River; (xi) Dungarvan River; (xii) Doaktown Upper; (xiii) Doaktown Across; (xiv) Blackville Across.

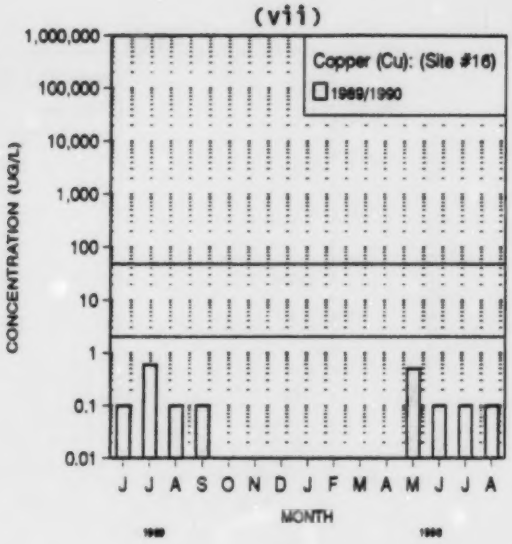
(Note: The horizontal line at 2 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 48 μg/L indicates the concentration at which juvenile Atlantic salmon die.)

[Graphs constructed from data collected by MREAC.]

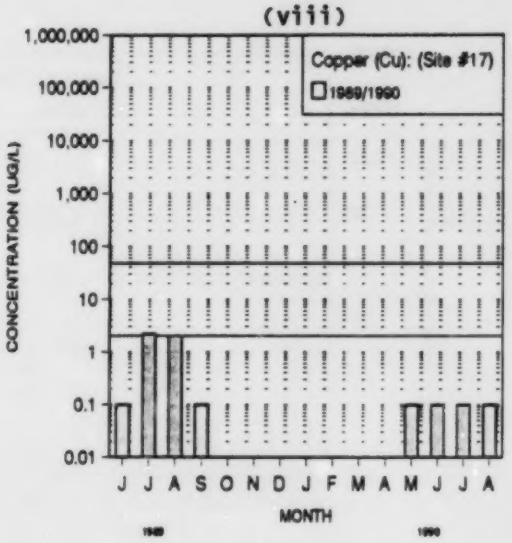
Figure 11


(i)
Copper (Cu): (Site #3)
1989/1990
(ii)
Copper (Cu): (Site #4)
1989/1990
(iii)
Copper (Cu): (Site #5)
1989/1990
(iv)
Copper (Cu): (Site #12)
1989/1990
(v)
Copper (Cu): (Site #13)
1989/1990
(vi)
Copper (Cu): (Site #14)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

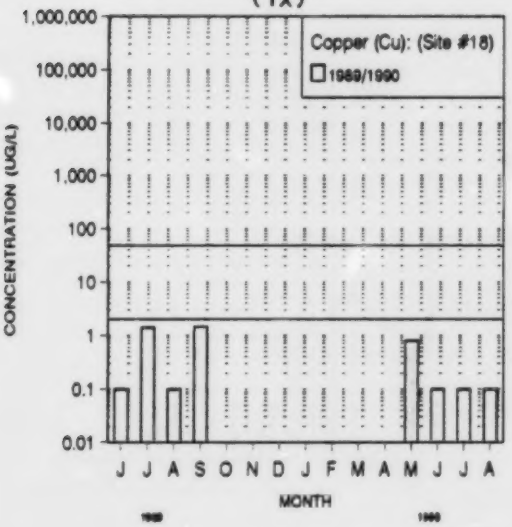
(vii)



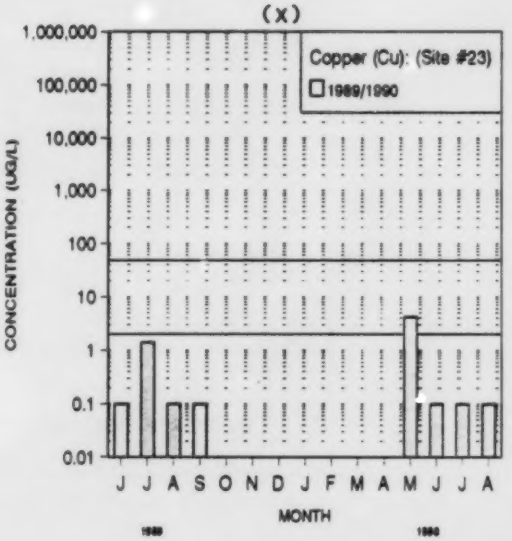
(viii)



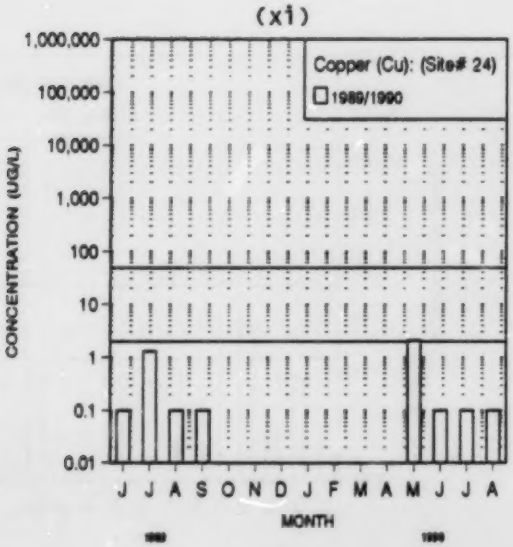
(ix)



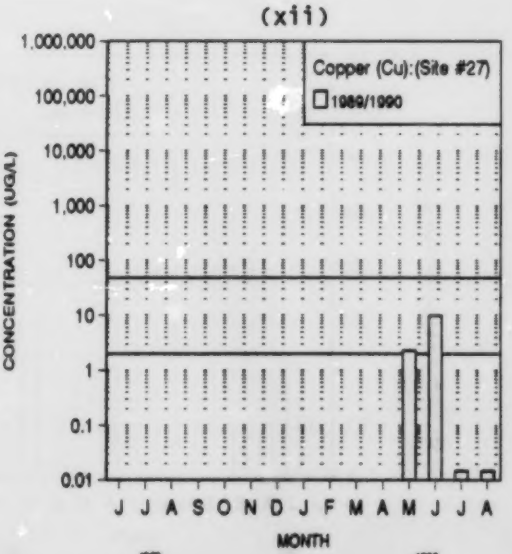
(x)



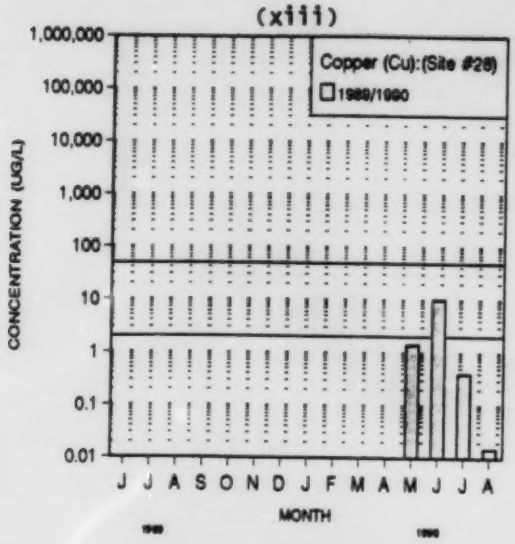
(xi)



(xii)



(xiii)


Copper (Cu):(Site #28)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(xiv)

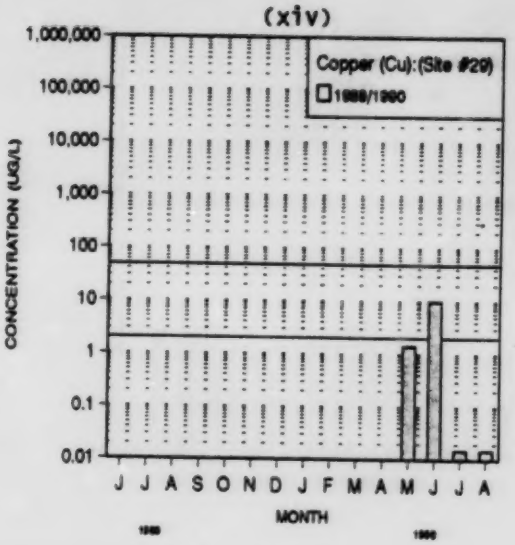
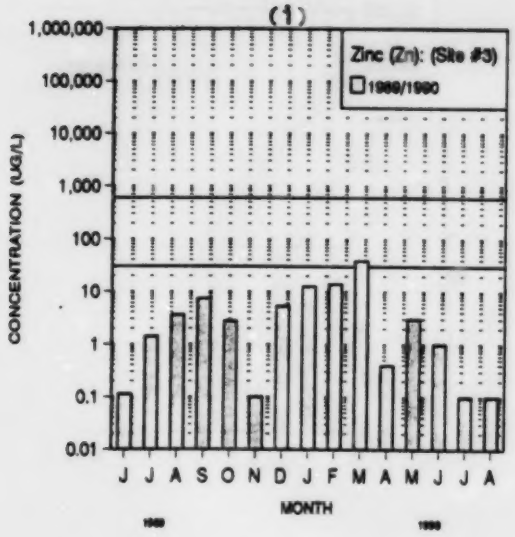
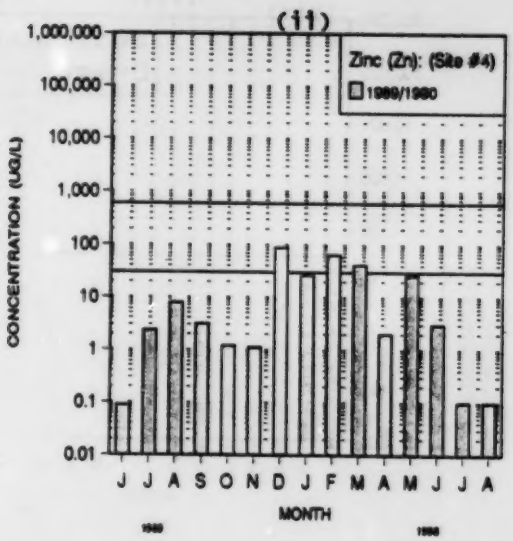

Copper (Cu):(Site #29)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

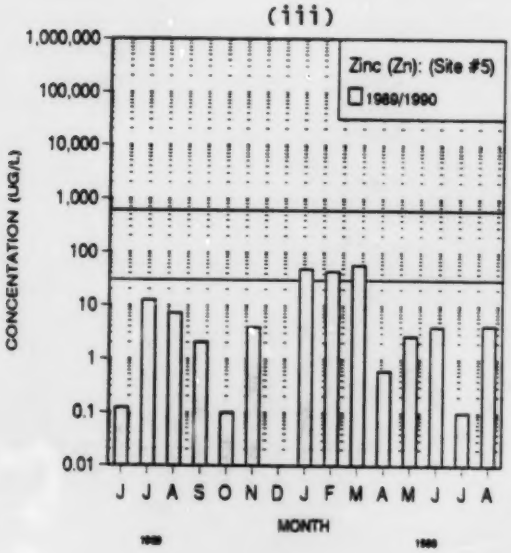
Figure 12. Concentrations of zinc in monthly samples collected from Group IIa sites: (i) Boisetown; (ii) Doaktown Bridge; (iii) Blackville; (iv) Ludlow; (v) Nelson's Hollow; (vi) Upper Blackville; (vii) Batholomew River; (viii) Quarryville; (ix) Barnaby River; (x) Renous River; (xi) Dungarvan River; (xii) Doaktown Upper; (xiii) Doaktown Across; (xiv) Blackville Across.

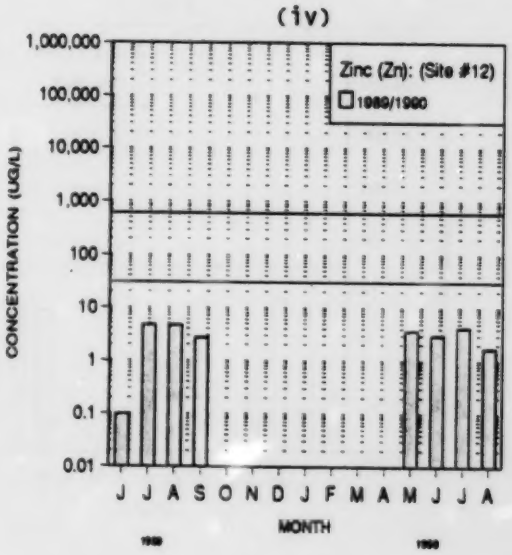
(**Note**: The horizontal line at 30 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines: the upper horizontal solid at 600 μg/L indicates the concentration at which juvenile Atlantic salmon die.)

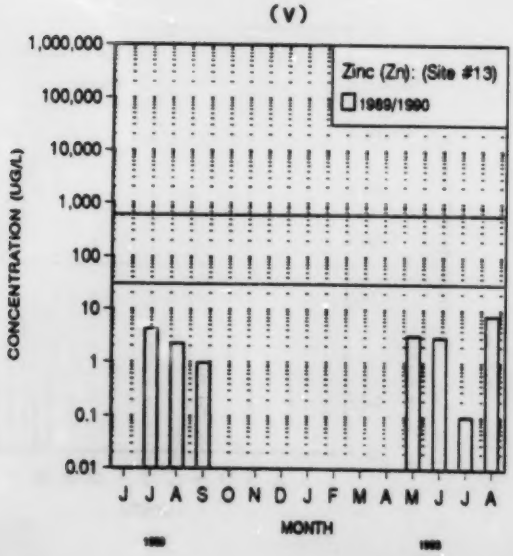
Figure 12

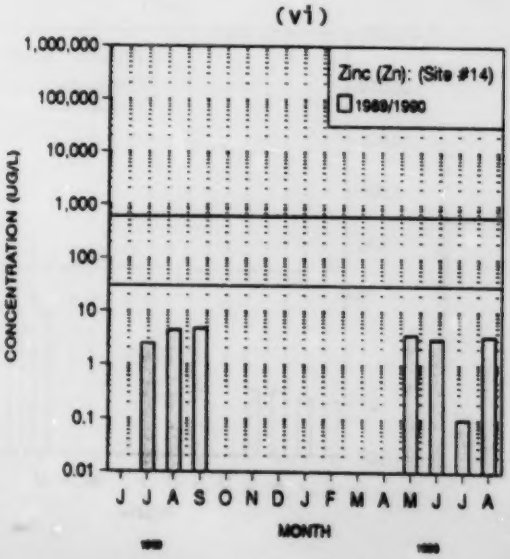

(i)
Zinc (Zn): (Site #3)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Zinc (Zn): (Site #4)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

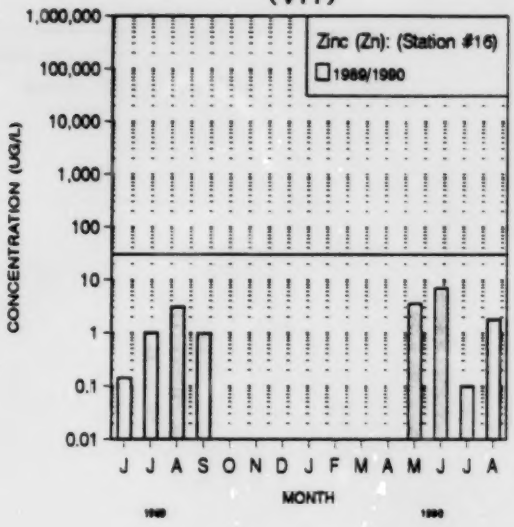

(iii)
Zinc (Zn): (Site #5)
1989/1990
CONCENTATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Zinc (Zn): (Site #12)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

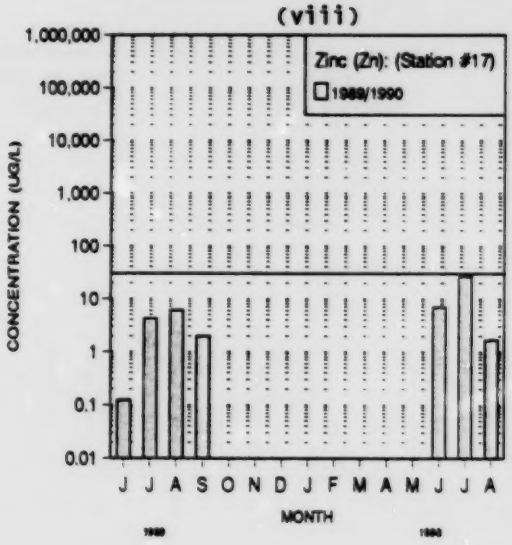

(v)
Zinc (Zn): (Site #13)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(vi)
Zinc (Zn): (Site #14)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

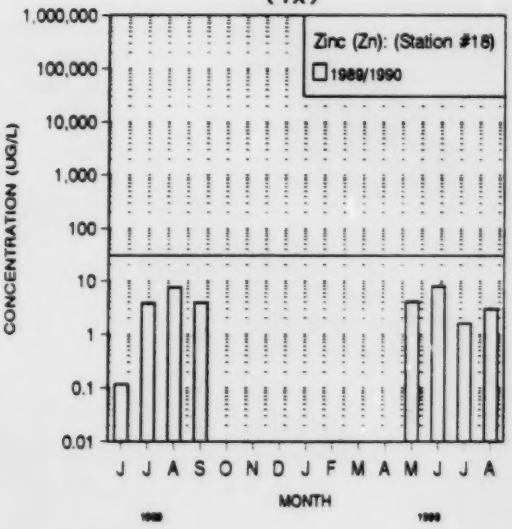
(vii)



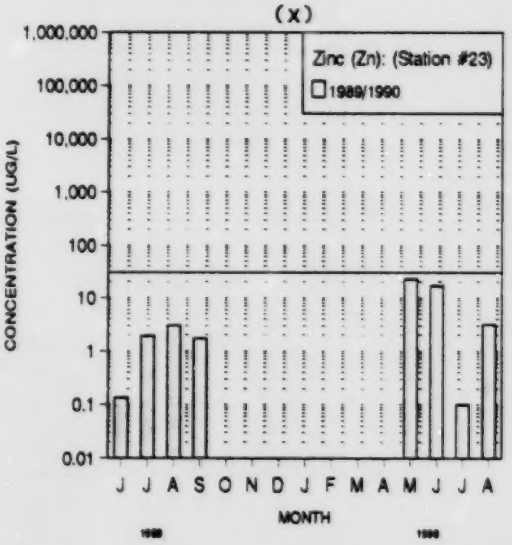
(viii)



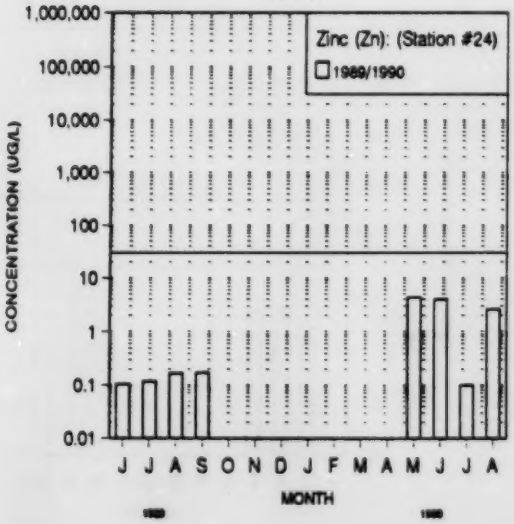
(ix)



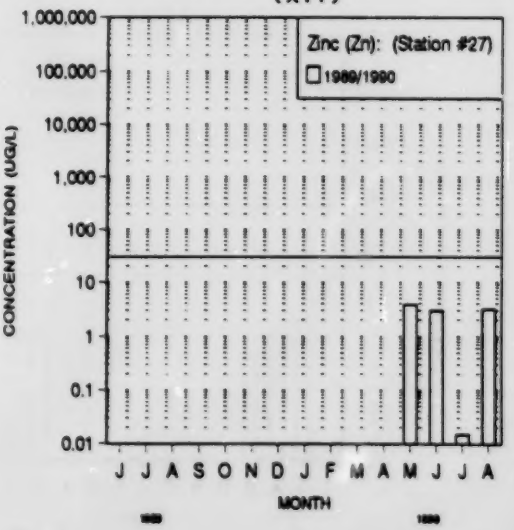
(x)



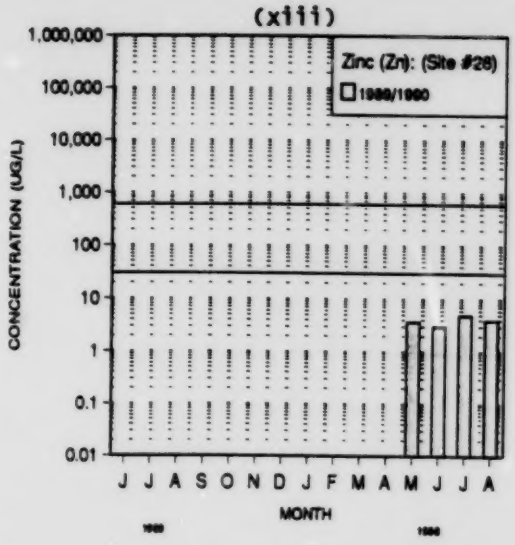
(xi)



(xii)



(xiii)


Zinc (Zn): (Site #28)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(xiv)

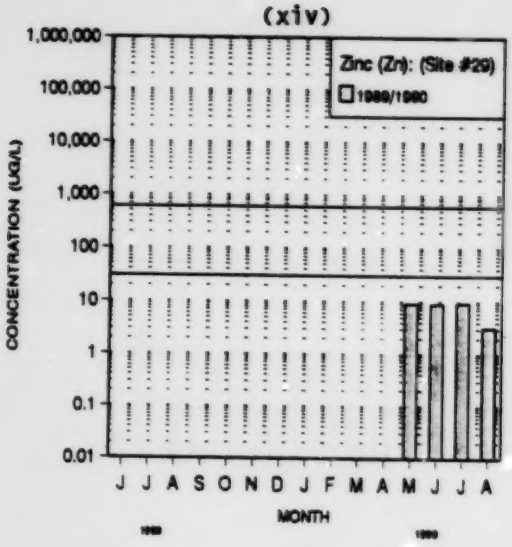
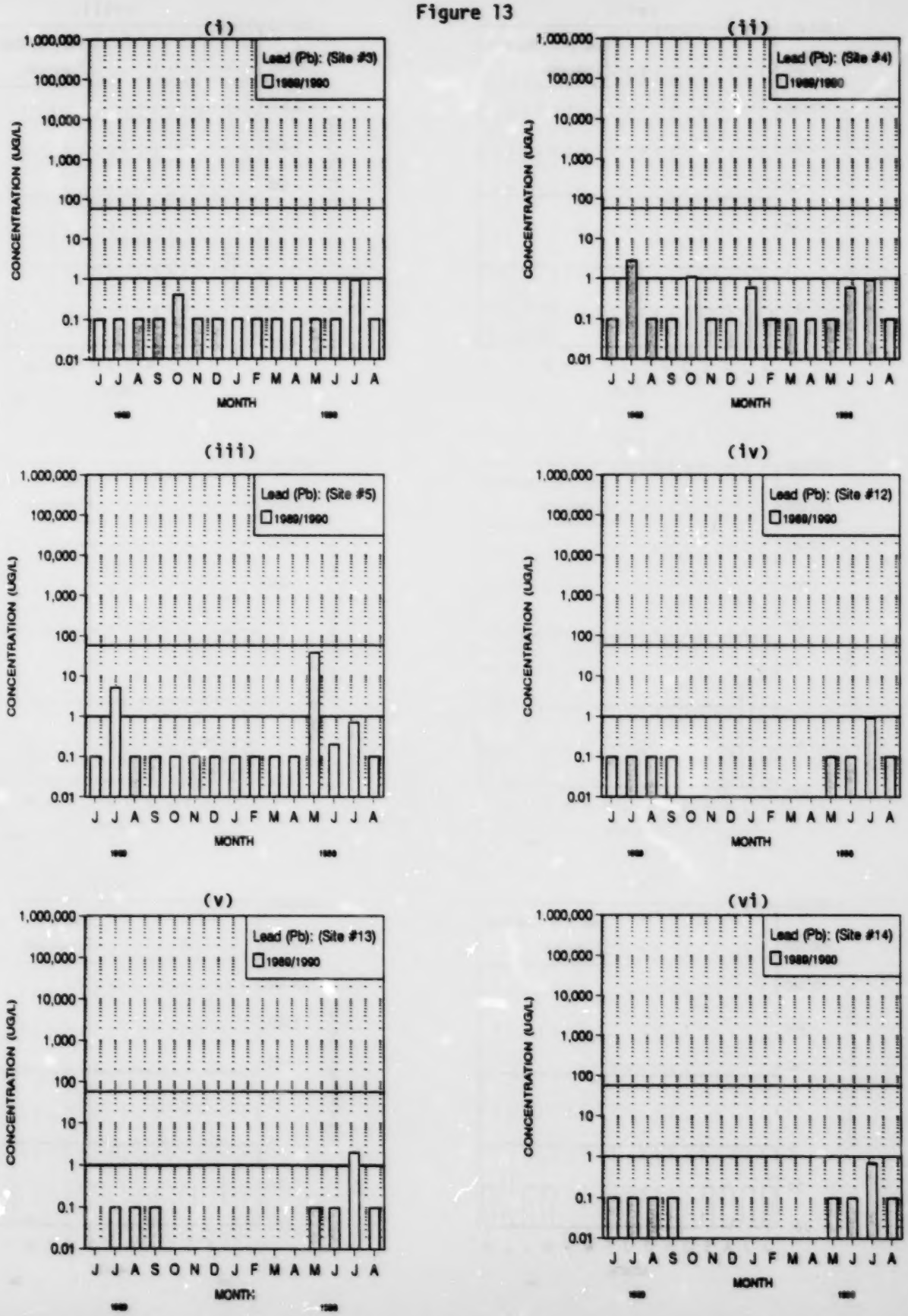

Zinc (Zn): (Site #29)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

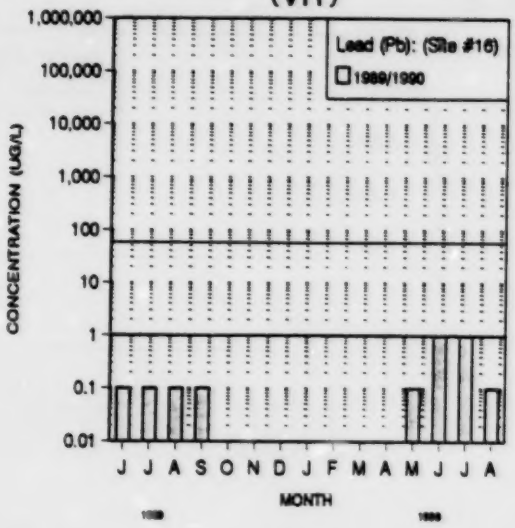
Figure 13. Concentrations of lead in monthly samples collected from Group IIa sites: (i) Boisetown; (ii) Doaktown Bridge; (iii) Blackville; (iv) Ludlow; (v) Nelson's Hollow; (vi) Upper Blackville; (vii) Batholomew River; (viii) Quarryville; (ix) Barnaby River; (x) Renous River; (xi) Dungarvan River; (xii) Doaktown Upper; (xiii) Doaktown Across; (xiv) Blackville Across.

(**Note**: The horizontal line at 1 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines: the upper horizontal line at 58 μg/L indicates the concentration at which juvenile Atlantic salmon die.)

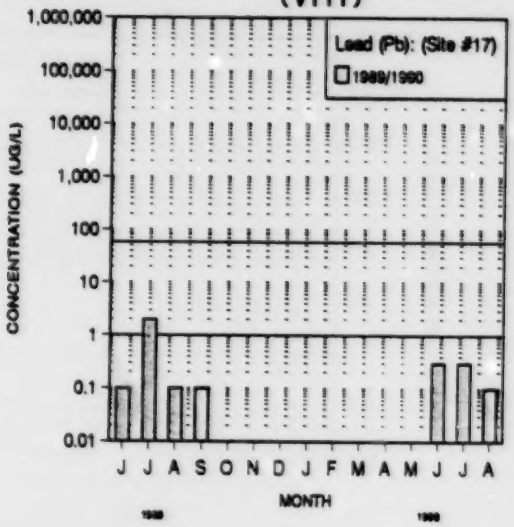
Figure 13


(i)
Lead (Pb): (Site #3)
1988/1990
(ii)
Lead (Pb): (Site #4)
1988/1990
(iii)
Lead (Pb): (Site #5)
1988/1990
(iv)
Lead (Pb): (Site #12)
1988/1990
(v)
Lead (Pb): (Site #13)
1988/1990
(vi)
Lead (Pb): (Site #14)
1988/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

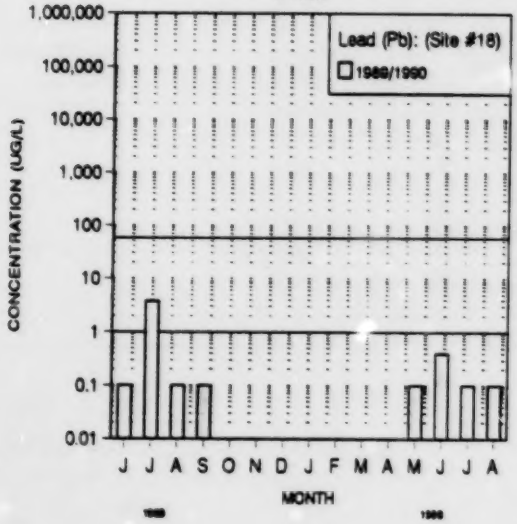
(vii)



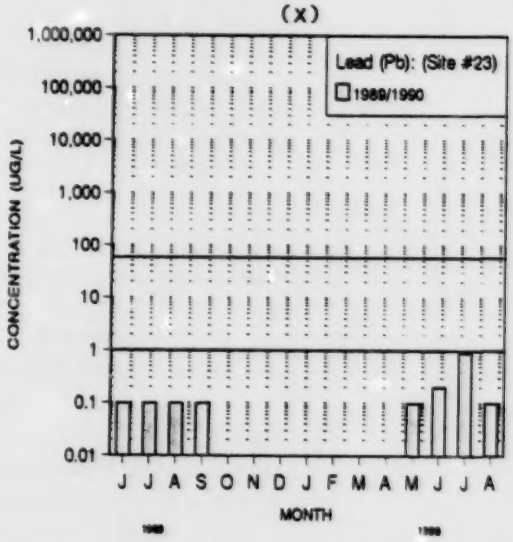
(viii)



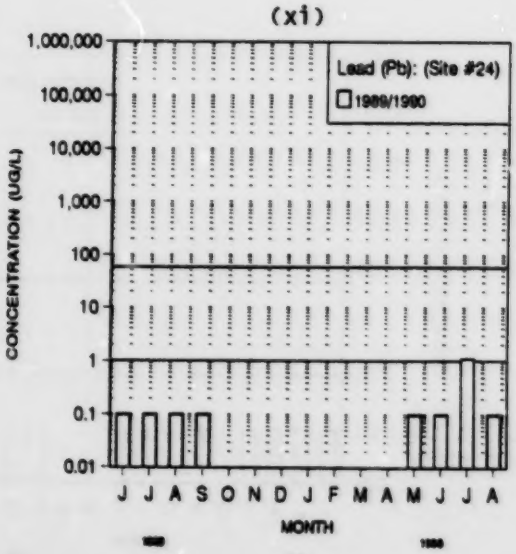
(ix)



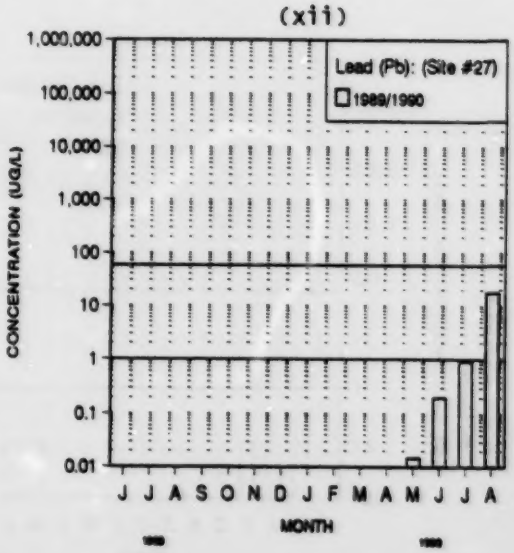
(x)



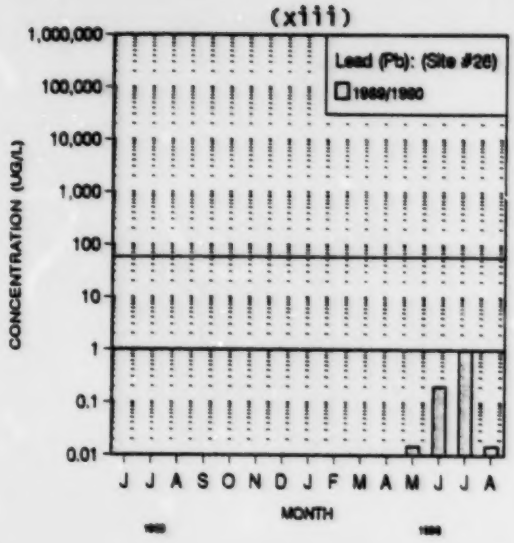
(xi)



(xii)



(xiii)


Lead (Pb): (Site #26)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

(xiv)

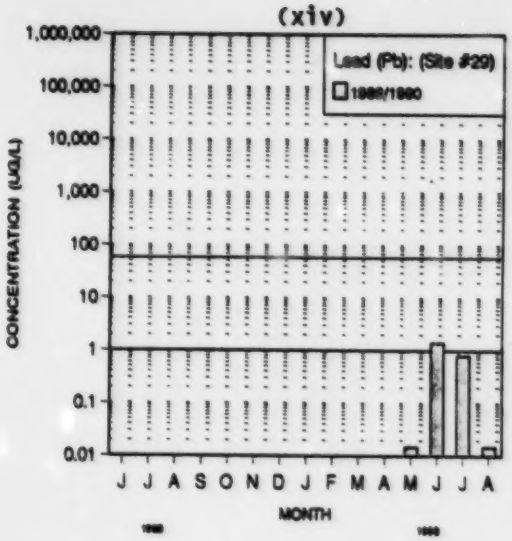
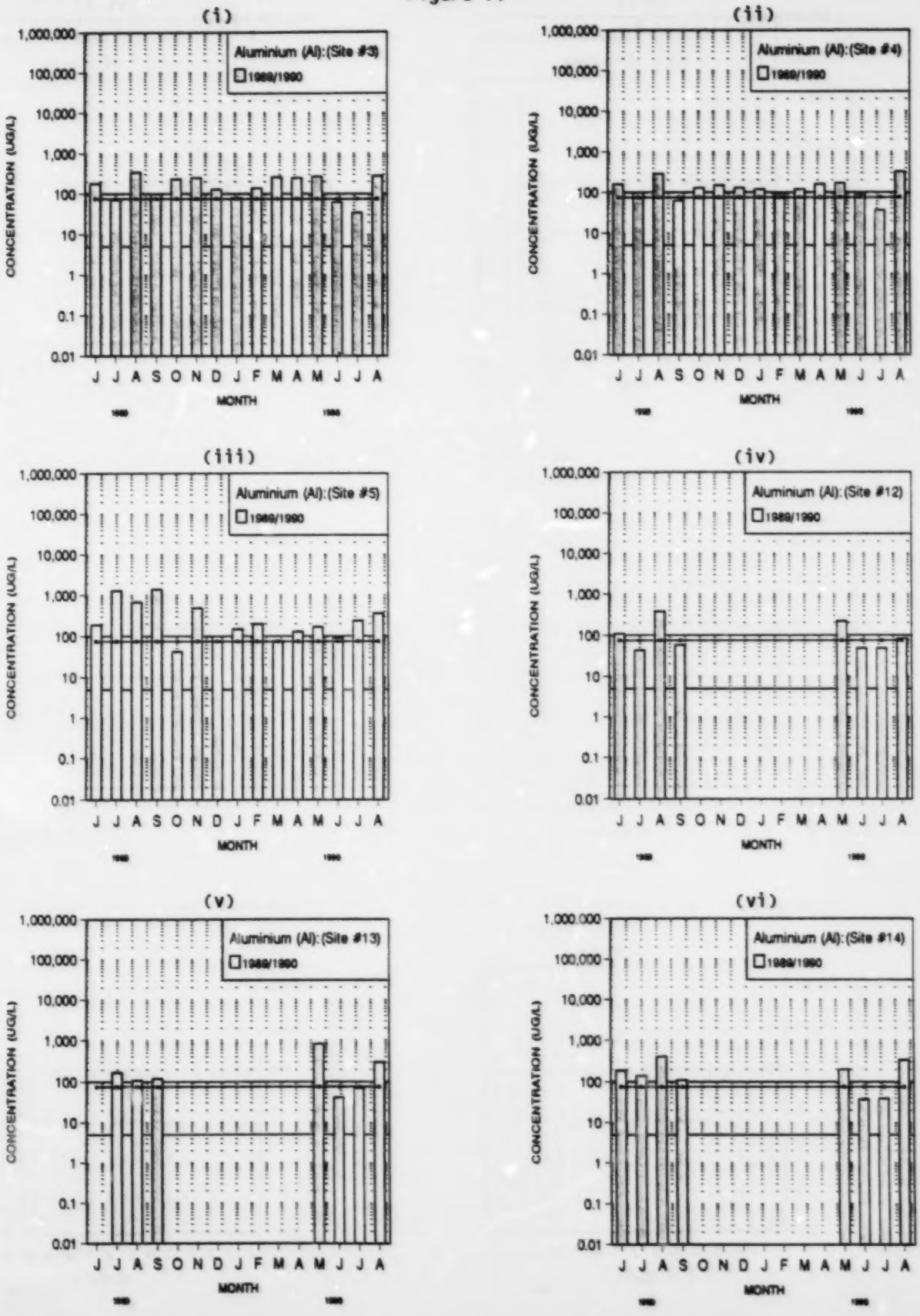

Lead (Pb): (Site #29)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

Figure 14. Concentrations of aluminum in monthly samples collected from Group IIa sites: (i) Boisetown; (ii) Doaktown Bridge; (iii) Blackville; (iv) Ludlow; (v) Nelson's Hollow; (vi) Upper Blackville; (vii) Batholomew River; (viii) Quarryville; (ix) Barnaby River; (x) Renous River; (xi) Dungarvan River; (xii) Doaktown Upper; (xiii) Doaktown Across; (xiv) Blackville Across.

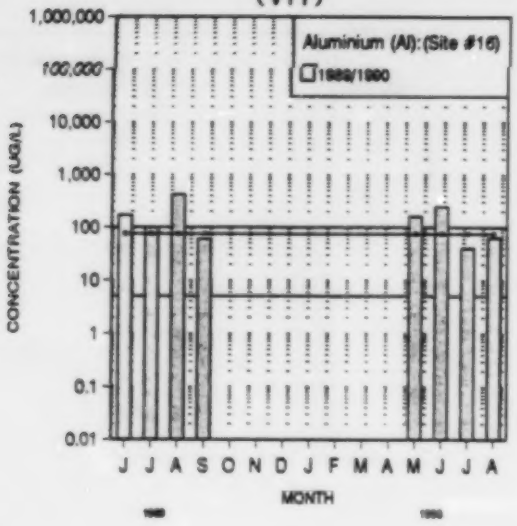
(**Note**: The horizontal lines at 5 μg/L and 100 μg/L indicate the "safe" concentrations recommended by the Canadian Freshwater Quality guidelines for water with a pH less than 6.5 and over 6.5 respectively; the horizontal line at 75 μg/L is the concentration shown to be lethal to juvenile rainbow trout at a pH of less than 6.5.)

[Graphs constructed from data collected by MREAC.]

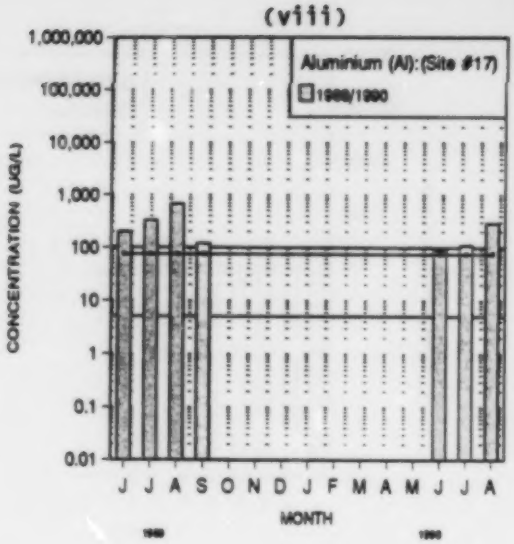
Figure 14


(i)
Aluminium (Al):(Site #3)
1989/1990
(ii)
Aluminium (Al):(Site #4)
1989/1990
(iii)
Aluminium (Al):(Site #5)
1989/1990
(iv)
Aluminium (Al):(Site #12)
1989/1990
(v)
Aluminium (Al):(Site #13)
1989/1990
(vi)
Aluminium (Al):(Site #14)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

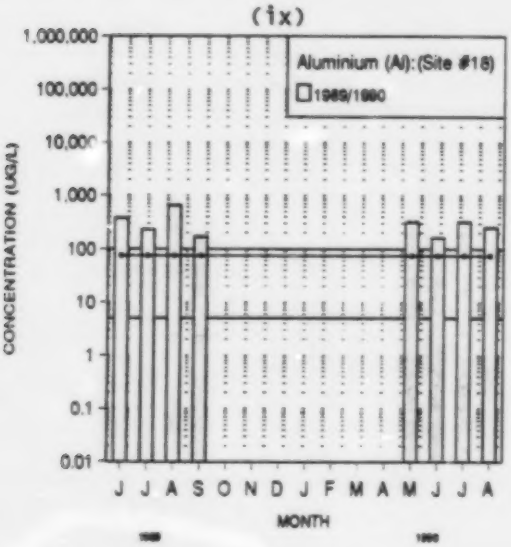
(vii)



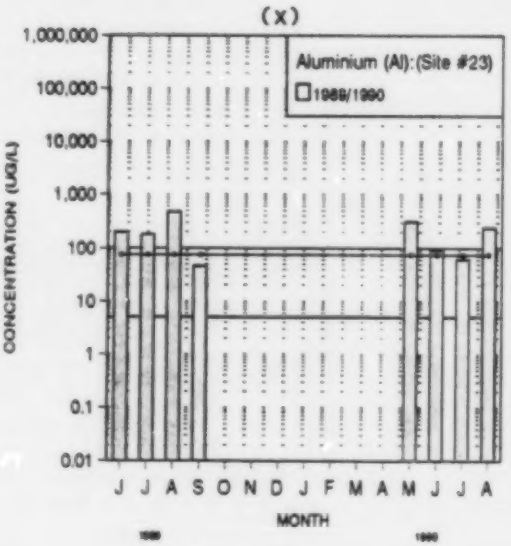
(viii)



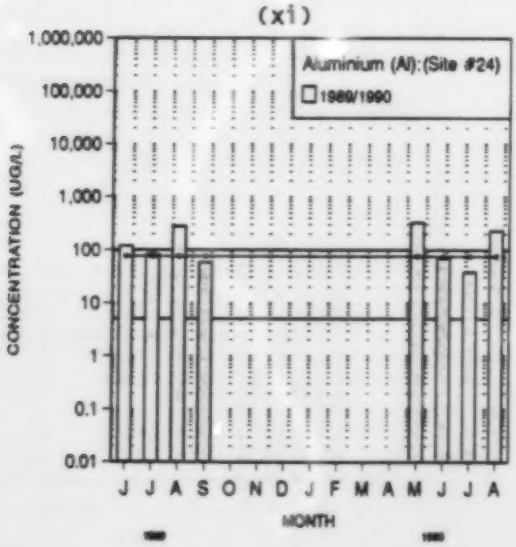
(ix)



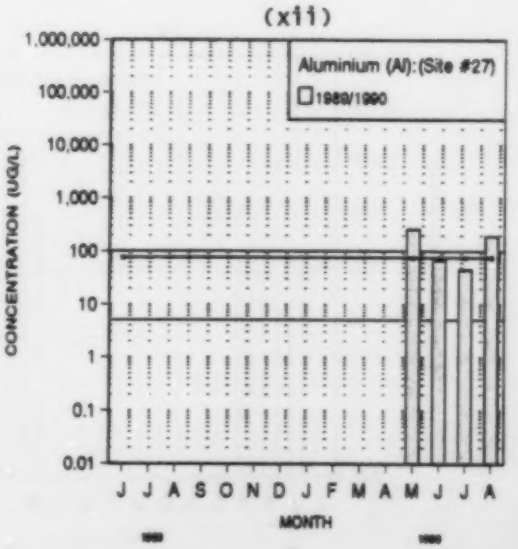
(x)



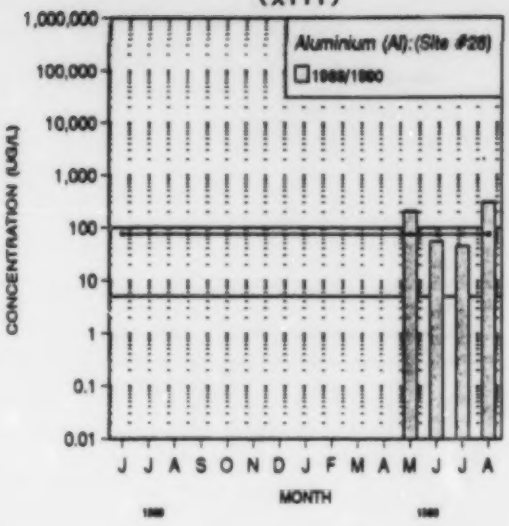
(xi)



(xii)



(xiii)


Aluminium (Al): (Site #28)
1988/1989
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(xiv)

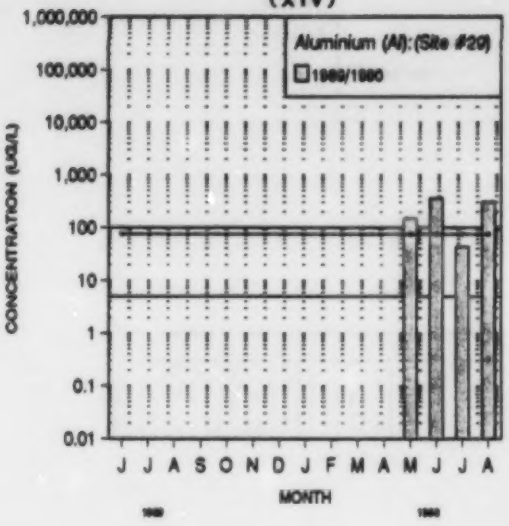
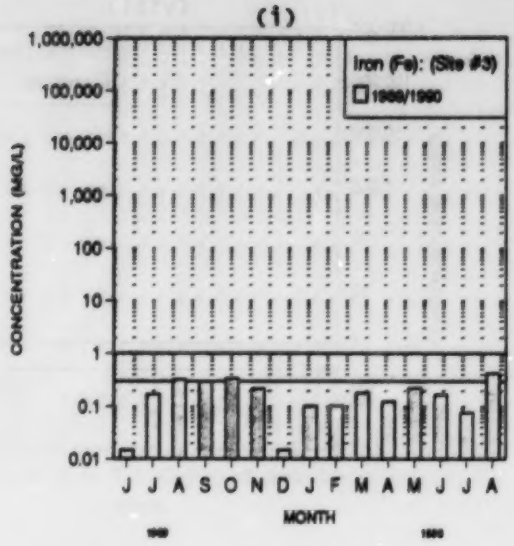

Aluminium (Al): (Site #29)
1988/1989
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

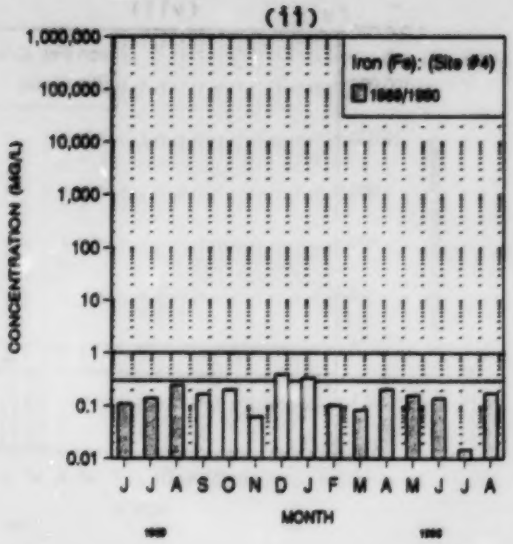
Figure 15. Concentrations of iron in monthly samples collected from Group IIa sites: (i) Boisetown; (ii) Doaktown Bridge; (iii) Blackville; (iv) Ludlow; (v) Nelson's Hollow; (vi) Upper Blackville; (vii) Batholomew River; (viii) Quarryville; (ix) Barnaby River; (x) Renous River; (xi) Dungarvan River; (xii) Doaktown Upper; (xiii) Doaktown Across; (xiv) Blackville Across.

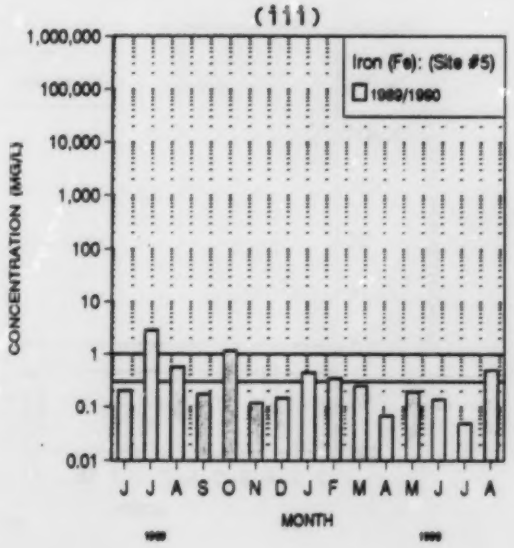
(Note: The horizontal line at 0.3 mg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 1.0 mg/L indicates the concentration at which fish start to die.)

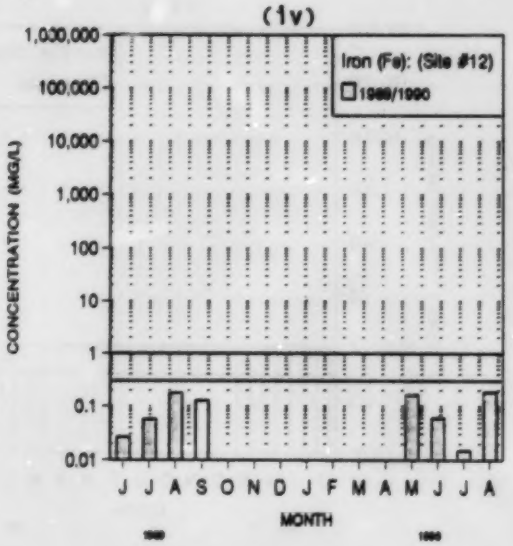
[Graphs constructed fram data collected by MREAC.]

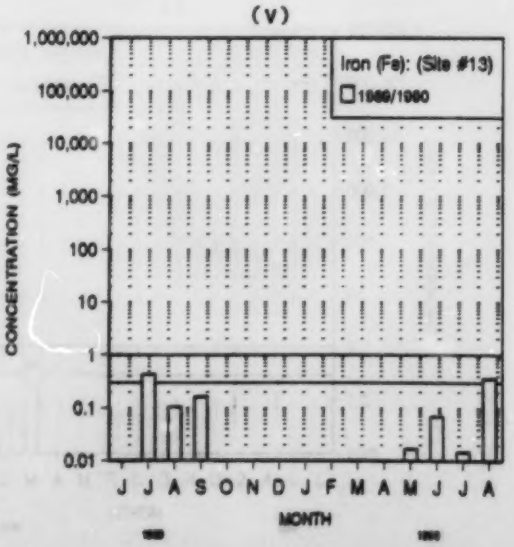
Figure 15

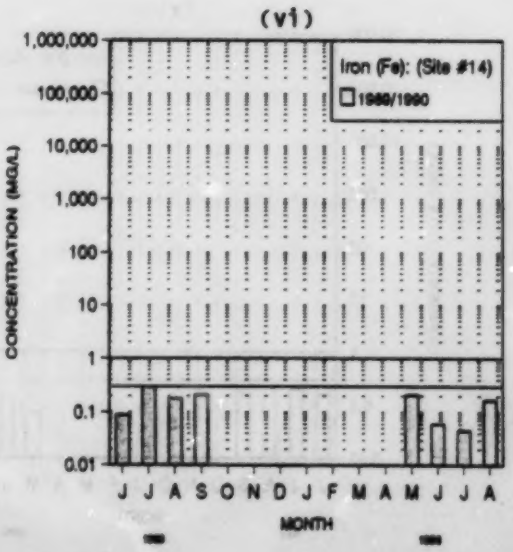

(i)
Iron (Fe): (Site #3)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Iron (Fe): (Site #4)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

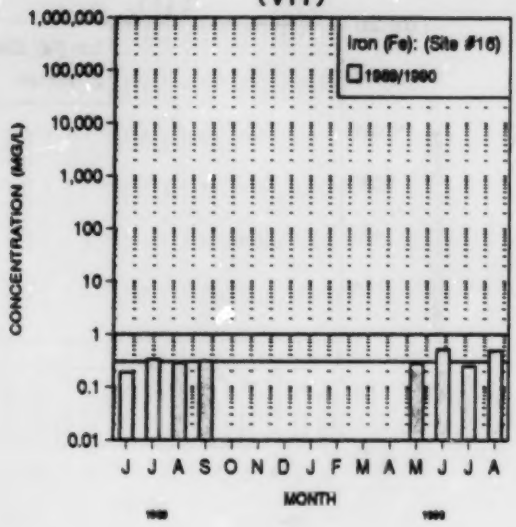

(iii)
Iron (Fe): (Site #5)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Iron (Fe): (Site #12)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

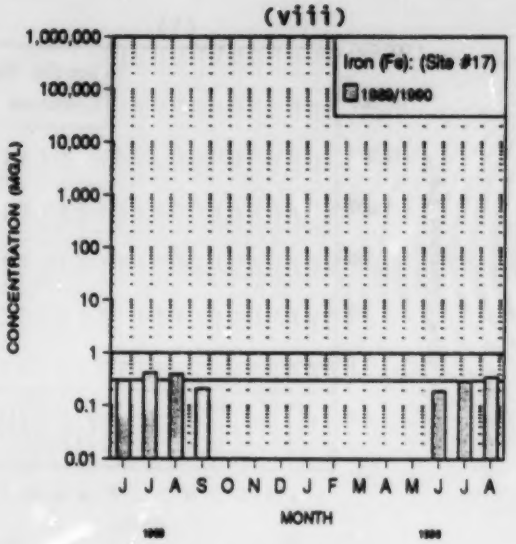

(v)
Iron (Fe): (Site #13)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(vi)
Iron (Fe): (Site #14)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

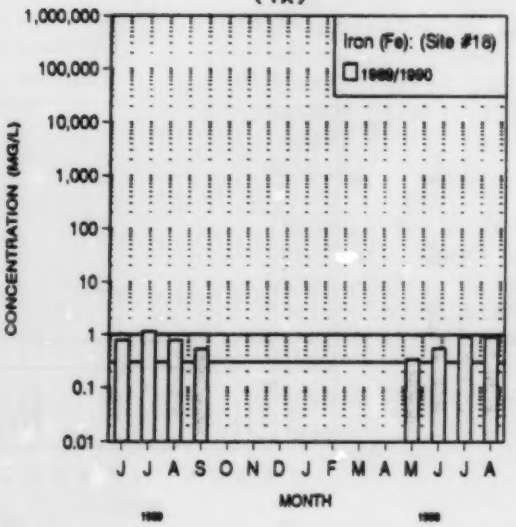
(vii)



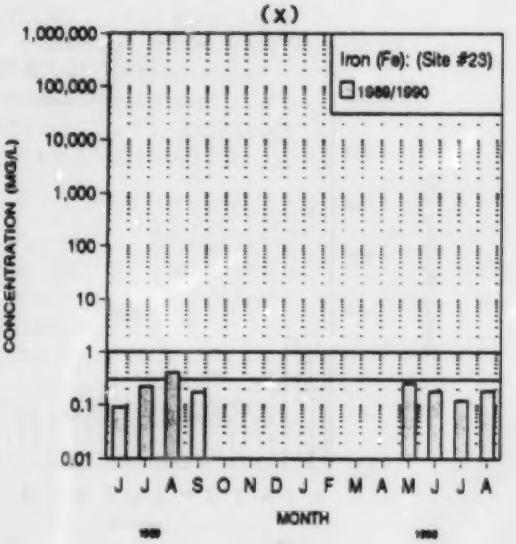
(viii)



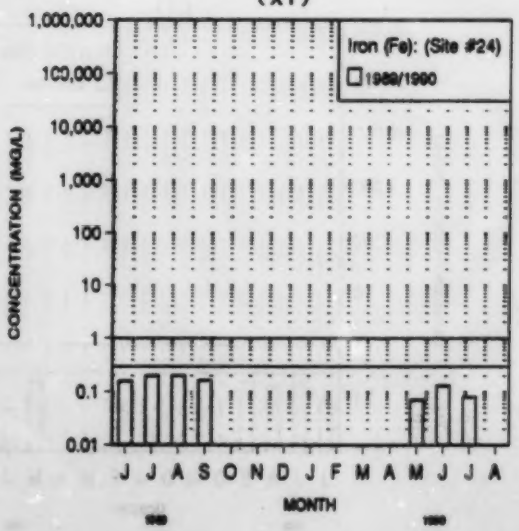
(ix)



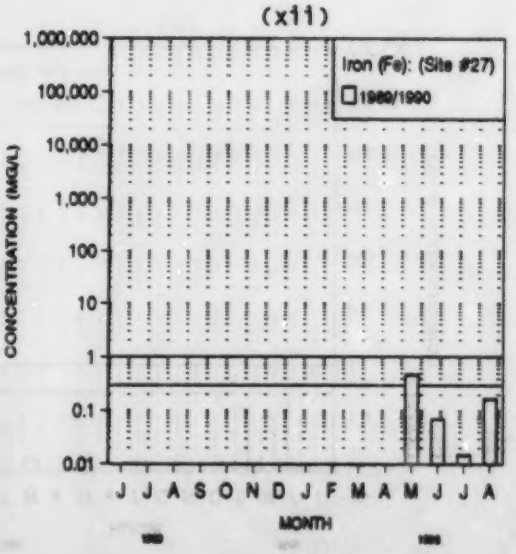
(x)



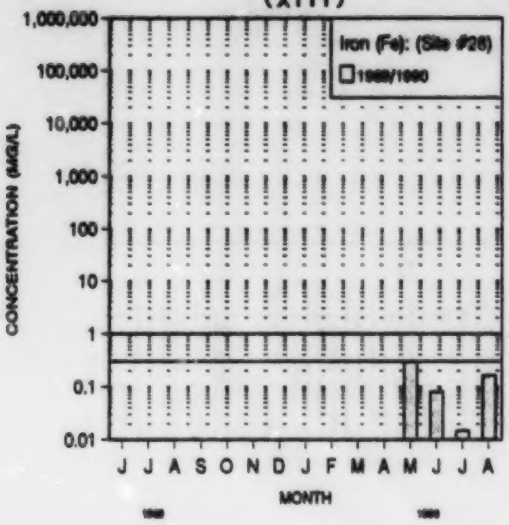
(xi)



(xii)



(xiii)


Iron (Fe): (Site #28)
1988/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

(xiv)

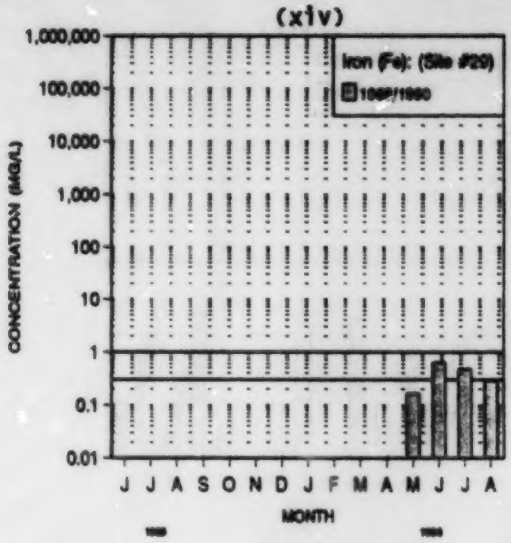

Iron (Fe): (Site #29)
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

Figure 16. Concentrations of copper in monthly samples collected from Group IIb sites: (i) Wayerton Bridge; (ii) Lyttleton Bridge; (iii) Miner's Bridge; and (iv) Tomogonops River.

(Note: The horizontal line at 2 μg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 48 μg/L is the concentration above which young Atlantic salmon will die.)

[Graph constructed from data collected by MREAC.]

Figure 16

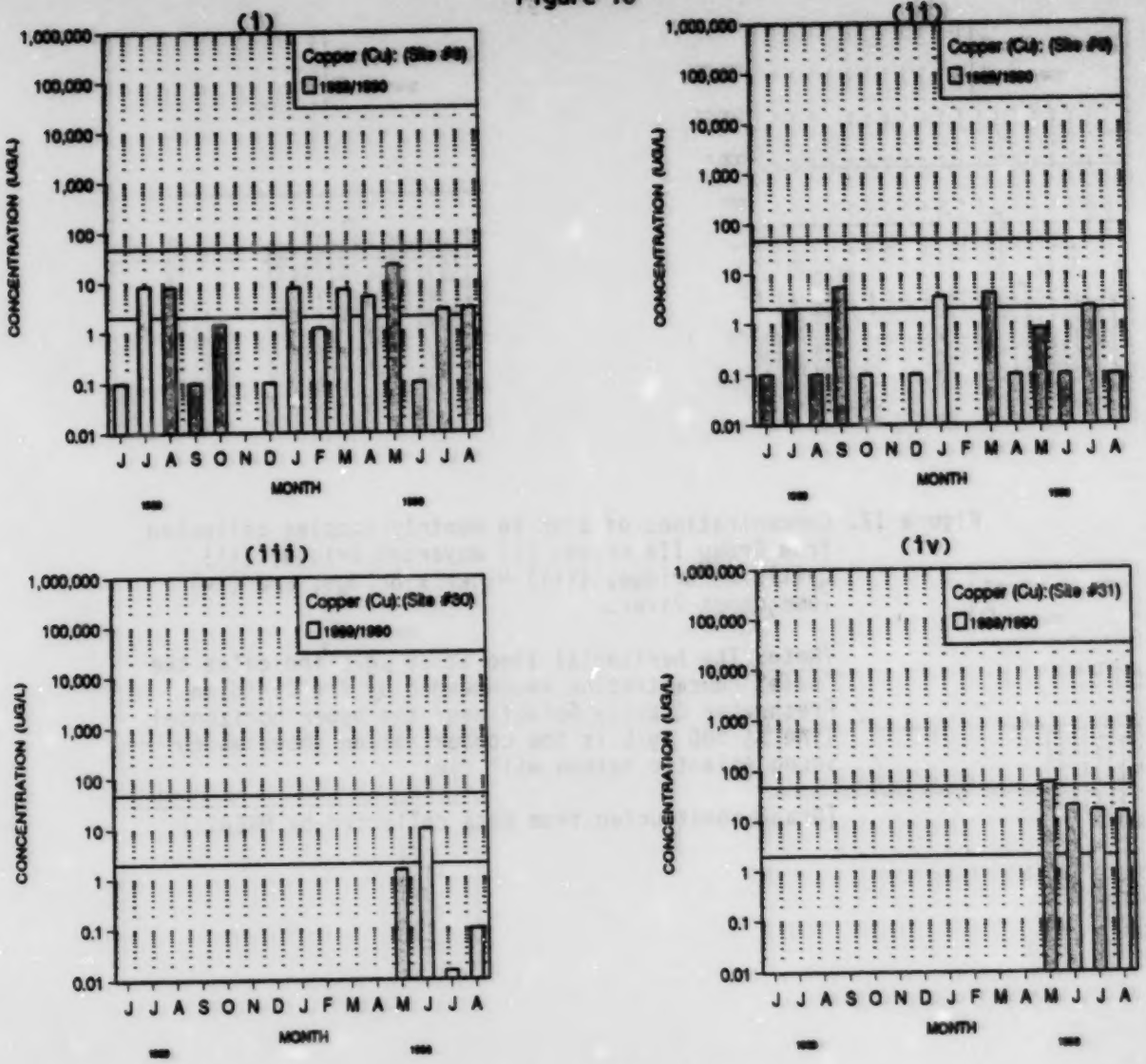
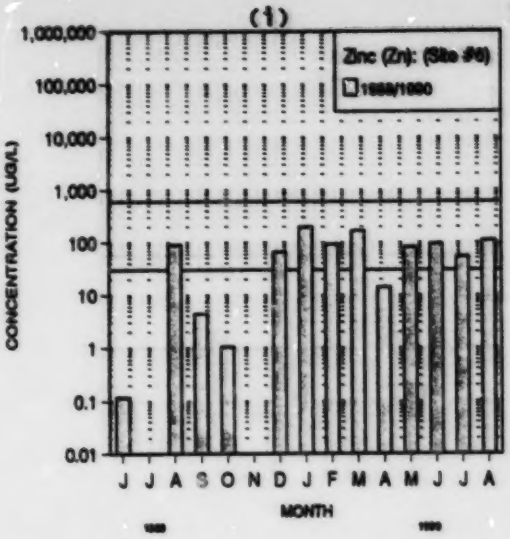

(i)
Copper (Cu): (Site #8)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH
(ii)
Copper (Cu): (Site #9)
1989/1990
CONCENTRATION (UG/L)
MONTH
(iii)
Copper (Cu):(Site #30)
1989/1990
CONCENTRATION (UG/L)
MONTH
(iv)
Copper (Cu):(Site #31)
1989/1990
CONCENTRATION (UG/L)
MONTH

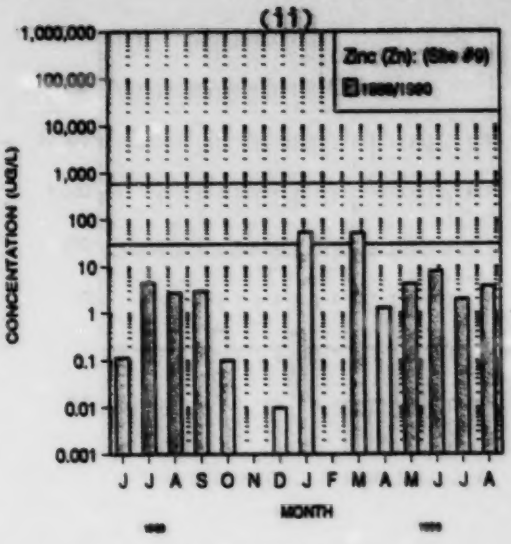
Figure 17. Concentrations of zinc in monthly samples collected from Group IIb sites: (i) Wayerton Bridge; (ii) Lyttleton Bridge; (iii) Miner's Bridge; and (iv) Tomogonops River.

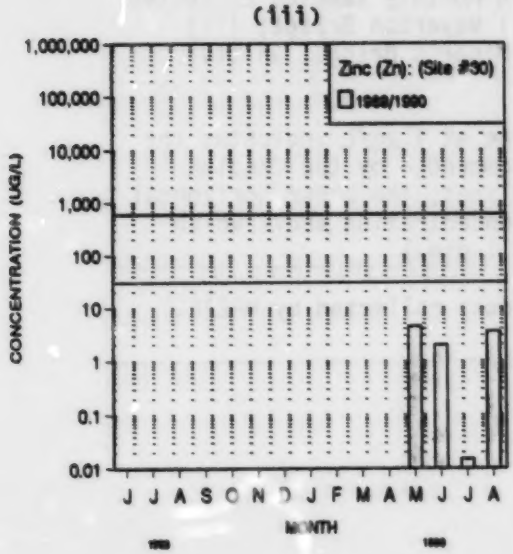
(Note: The horizontal line at 30 µg/L indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 600 µg/L is the concentration above which young Atlantic salmon will die).

[Graph constructed from data collected by MREAC.]

Figure 17


(i)
Zinc (Zn): (Site #6)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH


(ii)
Zinc (Zn): (Site #9)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
0.001
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH


(iii)
Zinc (Zn): (Site #30)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

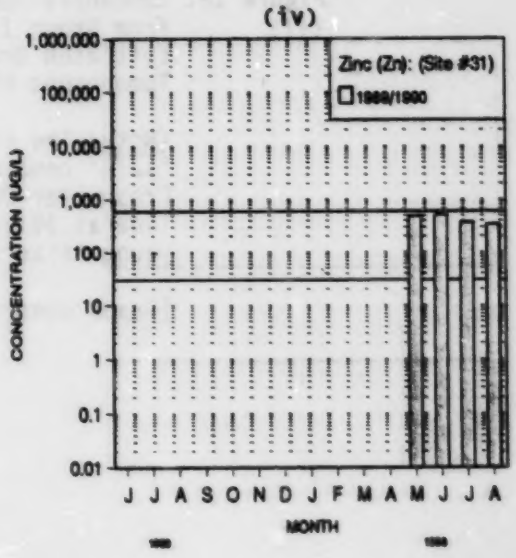
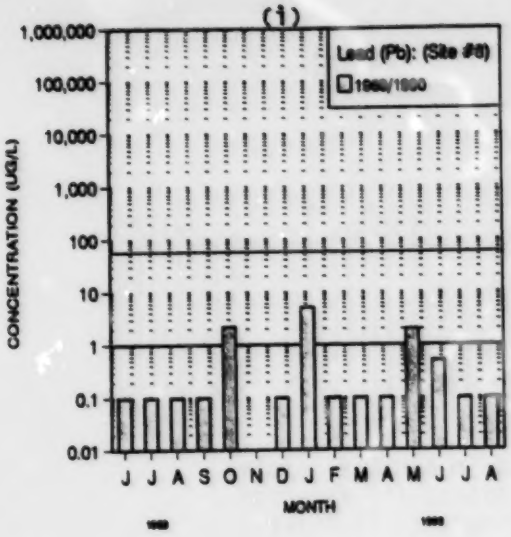

(iv)
Zinc (Zn): (Site #31)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

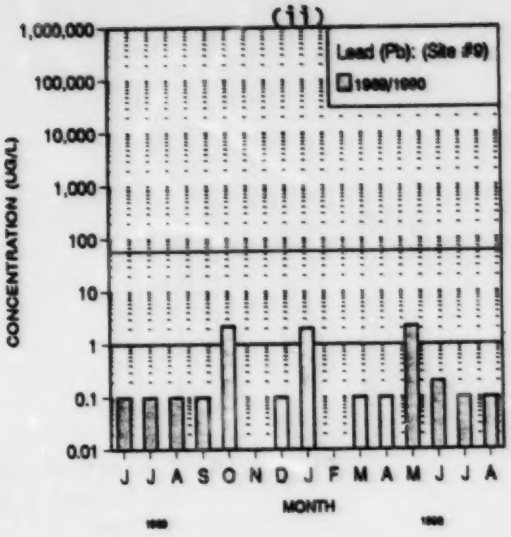
Figure 18. Concentrations of lead in monthly samples collected from Group IIb sites: (i) Wayerton Bridge; (ii) Lyttleton Bridge; (iii) Miner's Bridge; an (iv) Tomogonops River.

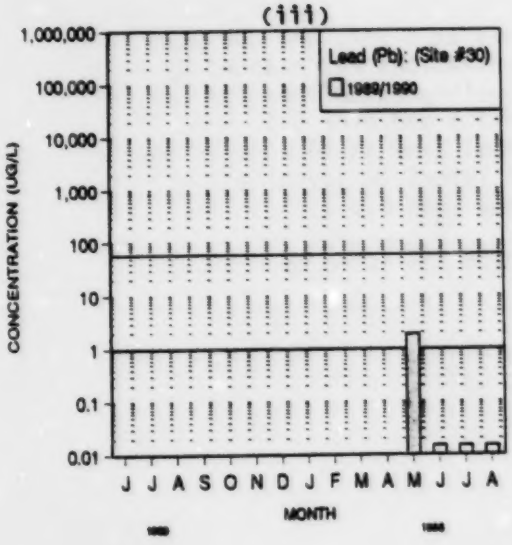
(**Note**: The horizontal line at 1 μg/L indicates the "safe" concentration recommended by the Candian Freshwater Quality Guidelines; the upper horizontal line at 58 μg/L is the concentration above which young Atlantic salmon will die.)

[Graph constructed from data collected by MREAC.]

Figure 18


(i)
Lead (Pb): (Site #8)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Lead (Pb): (Site #9)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iii)
Lead (Pb): (Site #30)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

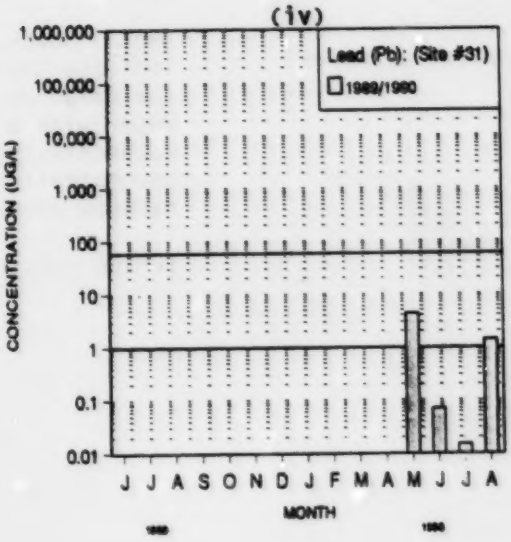

(iv)
Lead (Pb): (Site #31)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

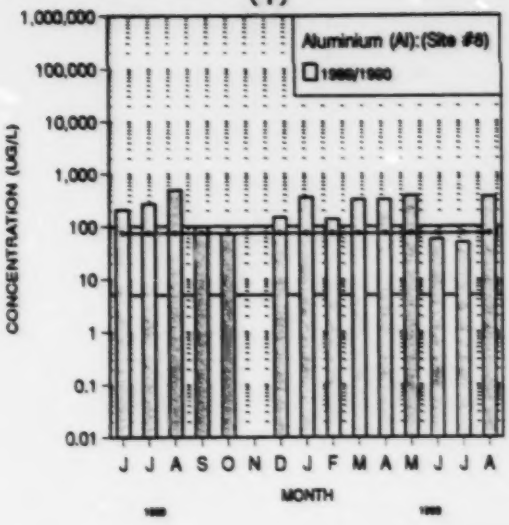
Figure 19. Concentrations of aluminum in monthly samples collected from Group IIb sites: (i) Wayerton Bridge; (ii) Lyttleton Bridge; (iii) Miner's Bridge; and (iv) Tomogonops River.

(**Note**: The horizontal lines at 5 µg/L and 100 µg/L indicate the "safe" concentrations recommended by the Canadian Freshwater Quality Guidelines for water with a pH less than 6.5 and over 6.5 respectively; the horizontal line at 75 µg/L is the concentration shown to be lethal to juvenile rainbow trout at pH of less than 6.5.)

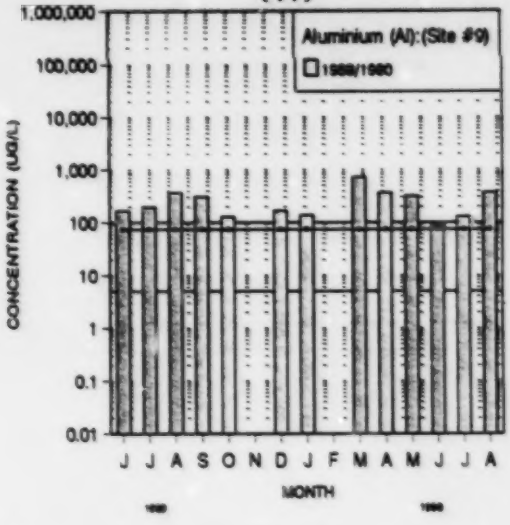
[Graph constructed from data collected by MREAC.]

Figure 19

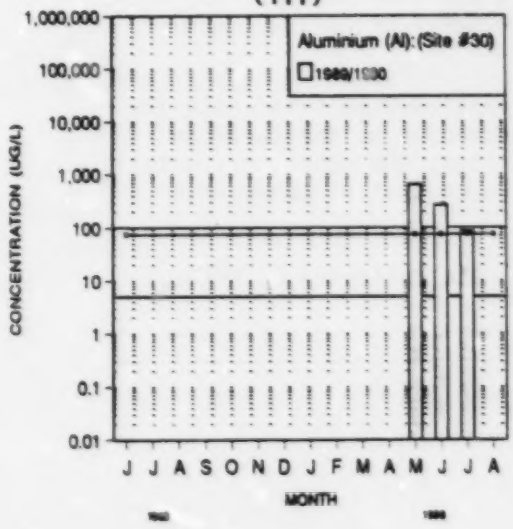
(i)



(ii)



(iii)



(iv)

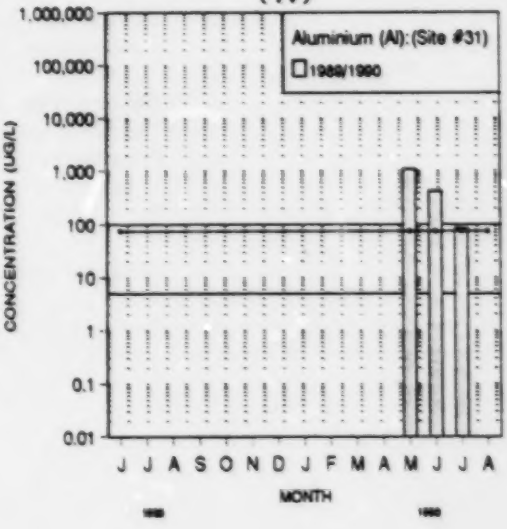
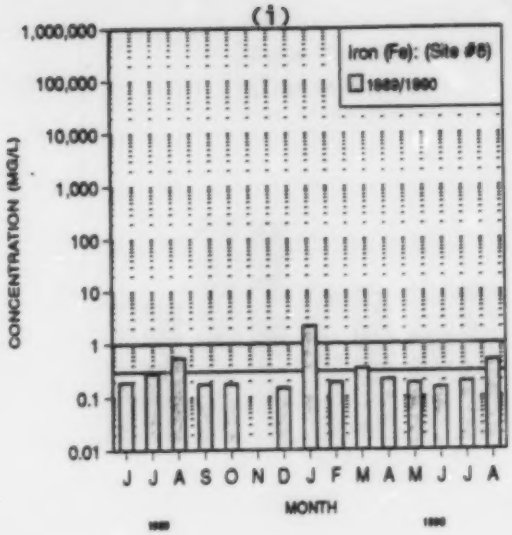


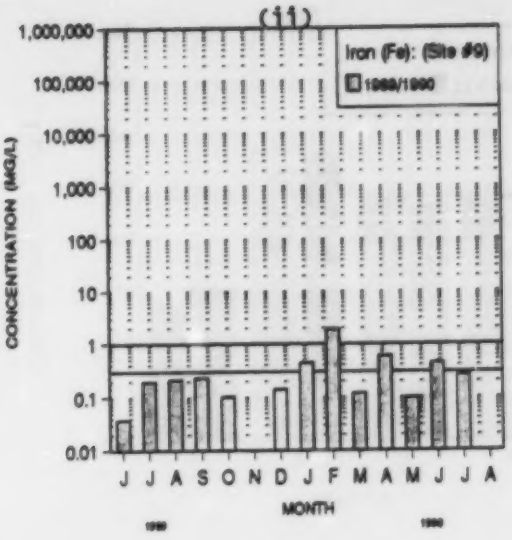
Figure 20. Concentrations of iron in monthly samples collected from Group IIb sites: (i) Wayerton Bridge; (ii) Lyttleton Bridge; (iii) Miner's Bridge; and (iv) Tomogonops River.

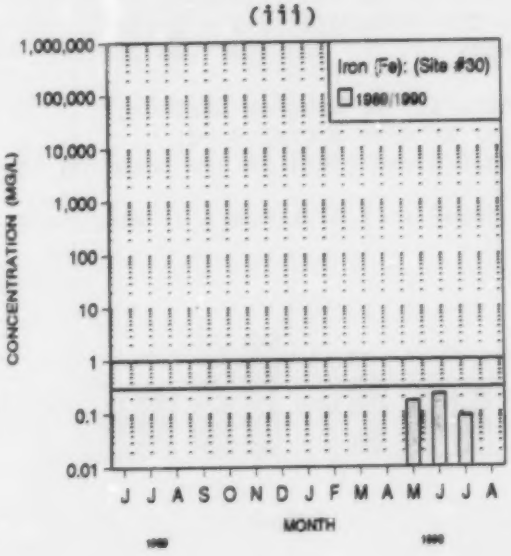
(Note: The horizontal line at 0.3 mg/L indicate the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines; the upper horizontal line at 1.0 mg/L is the concentration above which fish will start to die.)

[Graphs constructed from data collected by MREAC.]

Figure 20


(i)
Iron (Fe): (Site #8)
1989/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Iron (Fe): (Site #9)
1989/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iii)
Iron (Fe): (Site #30)
1989/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

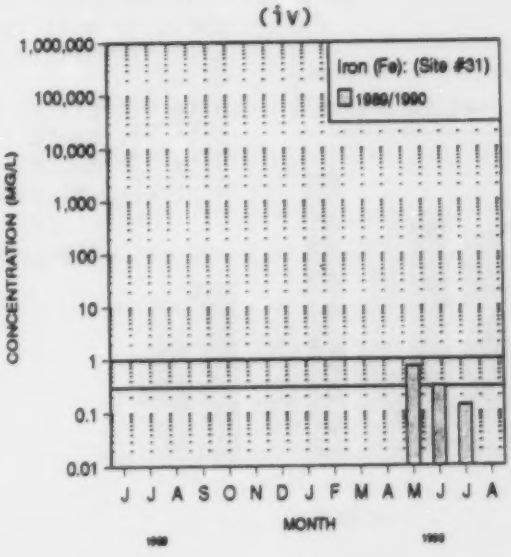
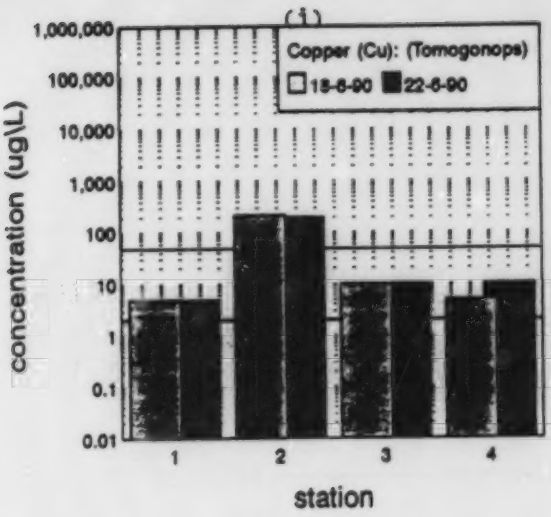
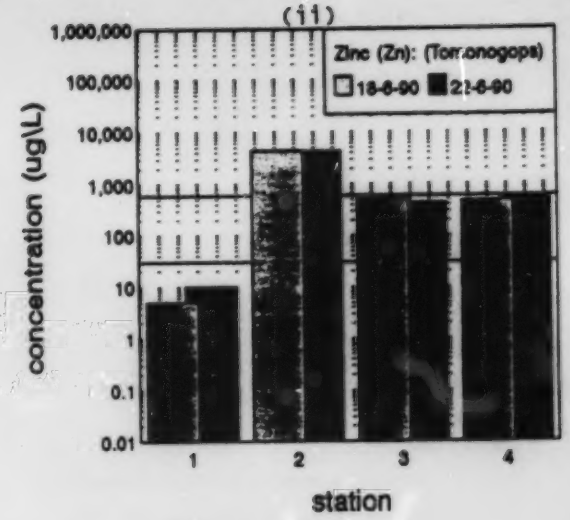
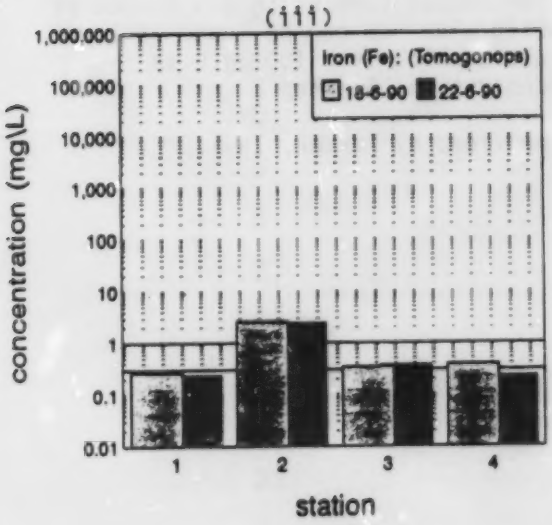

(iv)
Iron (Fe): (Site #31)
1989/1990
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

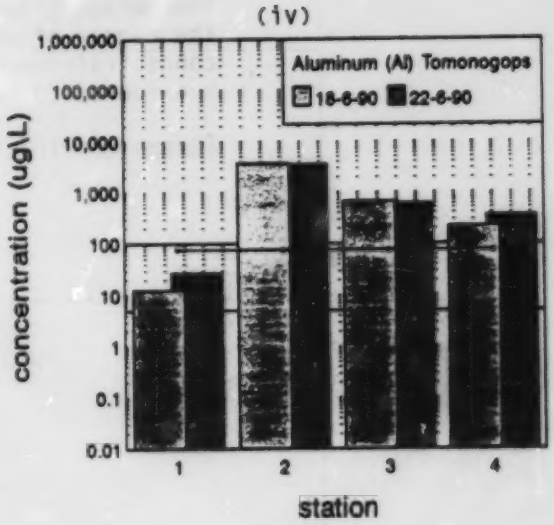
Figure 21. Concentrations of various metals in two water samples in June, 1990, from different sites in the Tomogonops River System.
Site P1: Little South tomogonops (at the Dam upstream of the mine);
Site P2: Little South Tomogonops at the Guaging Station;
Site P3: South Tomogonops River at mine access road;
Site P4: Mouth of the tomogonops River (just before entering the Northwest Miramichi River).
(i) Copper; (ii) Zinc; (iii) Iron; (iv) Aluminum; (v) Manganese; and (vi) Magnesium.

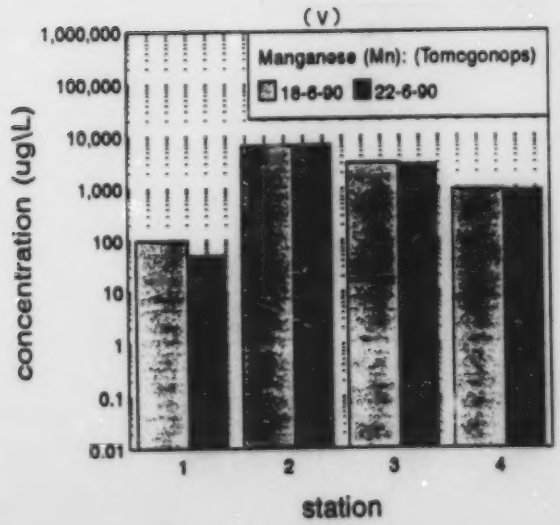
Figure 21


(i)
Copper (Cu): (Tomogonops)
18-6-90
22-6-90
concentration (ug\L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
1
2
3
4
station


(ii)
Zinc (Zn): (Tomogonops)
18-6-90
22-6-90
concentration (ug\L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
1
2
3
4
station


(iii)
Iron (Fe): (Tomogonops)
18-6-90
22-6-90
concentration (mg\L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
1
2
3
4
station


(iv)
Aluminum (Al) Tomonogops
18-6-90
22-6-90
concentration (ug\L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
1
2
3
4
station


(v)
Manganese (Mn): (Tomogonops)
18-6-90
22-6-90
concentration (ug\L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
1
2
3
4
station

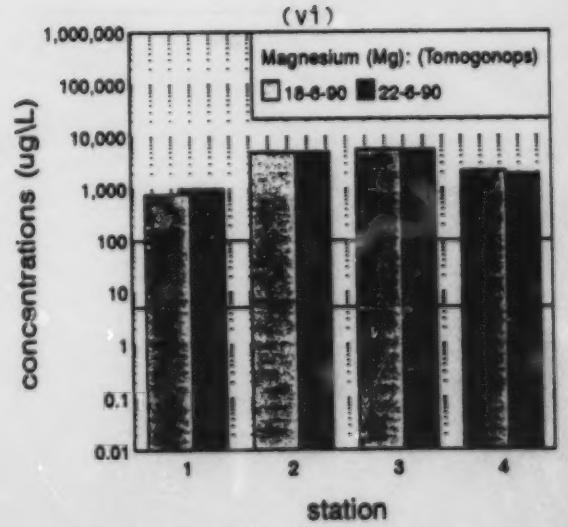

(vi)
Magnesium (Mg): (Tomogonops)
18-6-90
22-6-90
concentrations (ug\L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
1
2
3
4
station

Figure 22. Minimum and maximum pH values at Sites P1, P2, P3, and P4 on the Tomogonops River System. The horizontal line at pH 6.5 indicates the degree of acidity below which aluminum can be toxic at low concentrations (75 μg/L) and above which even 100 μg/L is considered to be a "safe" concentration. See Map 5.

[Graph constructed from data provided by Parker, 1991.]

Figure 22

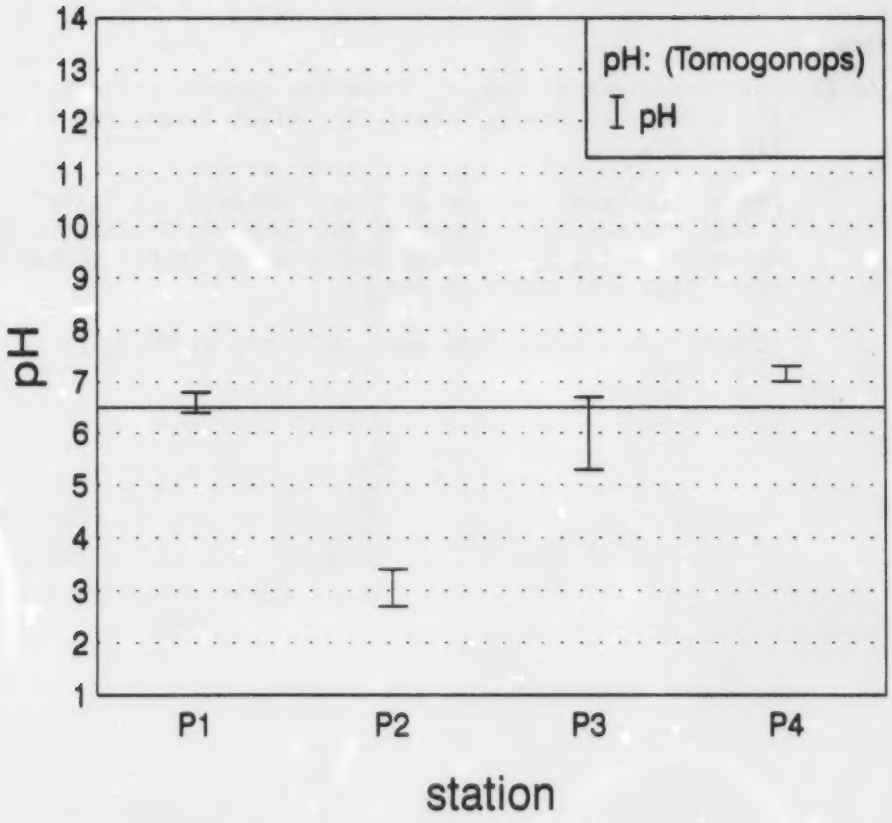
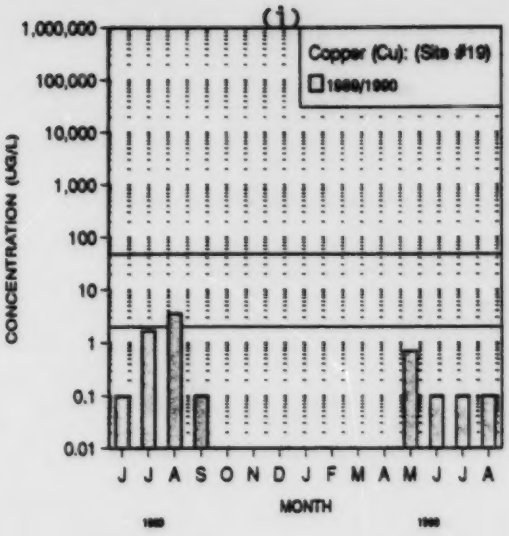

pH: (Tomogonops)
pH
14
13
12
11
10
9
8
7
6
5
4
3
2
1
pH
P1
P2
P3
P4
station

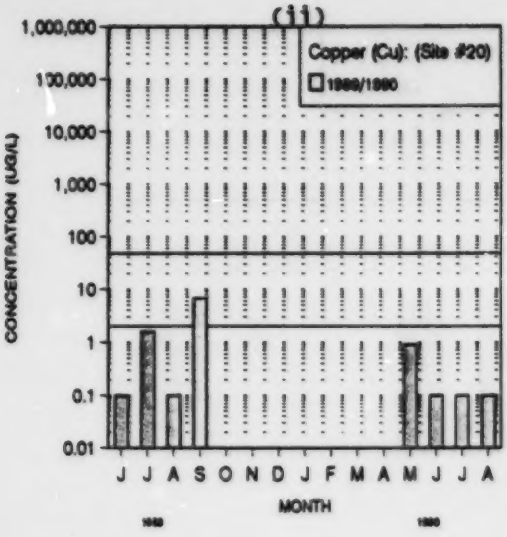
Figure 23. Concentrations of copper in monthly samples collected from Group III Sites: (i) Nappan River; (ii) Black River; and (iii) Baie du Vin River.

[**Note**: The lower horizontal lines indicate the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the upper lines indicate the lethal concentration at which fish will start to die.]

[Graphs constructed from data collected by MREAC.]

Figure 23


(i)
Copper (Cu): (Site #19)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Copper (Cu): (Site #20)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

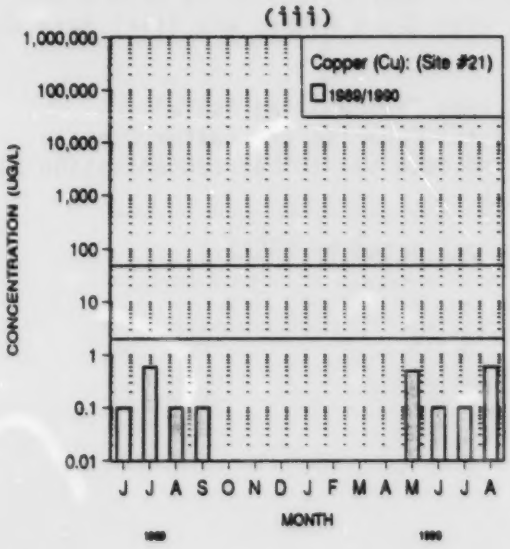
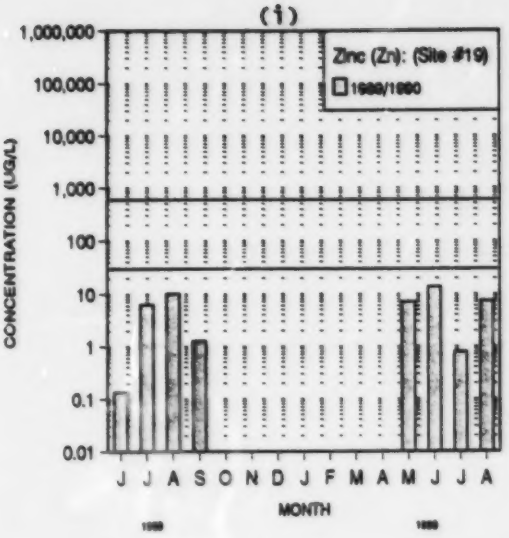

(iii)
Copper (Cu): (Site #21)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

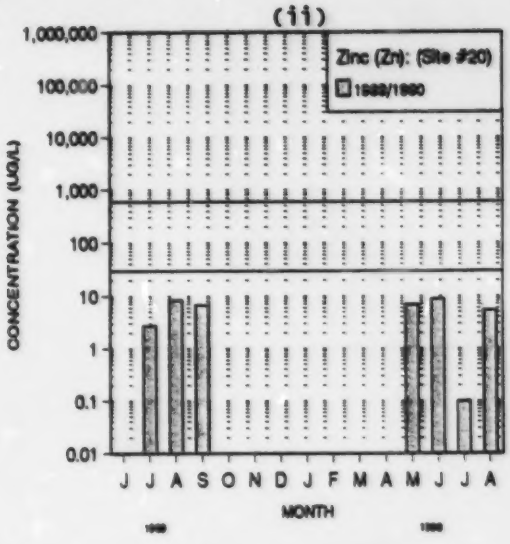
Figure 24. Concentrations of zinc in monthly samples collected from Group III Sites: (i) Nappan River; (ii) Black River; and (iii) Baie du Vin River.

[**Note**: The lower horizontal lines indicate the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the upper lines indicate the lethal concentration at which fish will start to die.]

[Graphs constructed from data collected by MREAC.]

Figure 24


(i)
Zinc (Zn): (Site #19)
1988/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Zinc (Zn): (Site #20)
1988/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

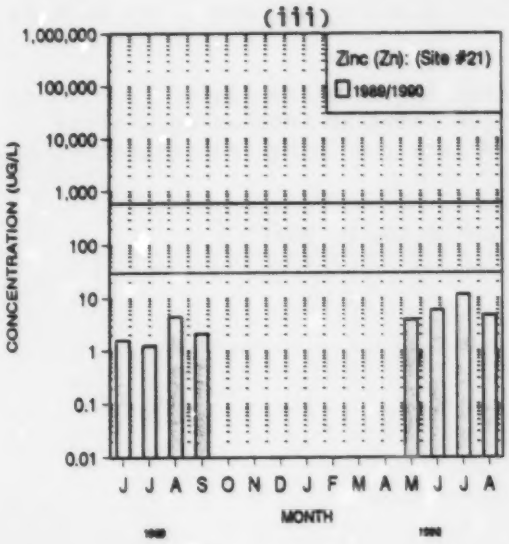
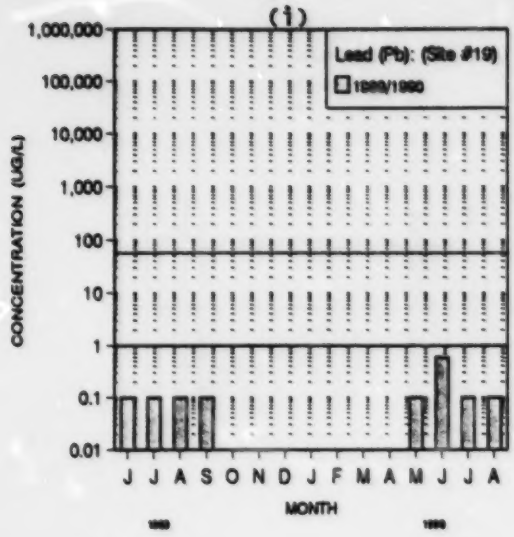

(iii)
Zinc (Zn): (Site #21)
1988/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

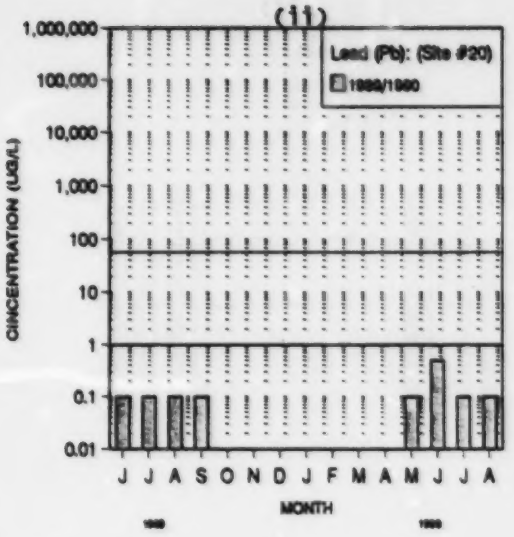
Figure 25. Concentrations of lead in monthly samples collected from Group III Sites: (i) Nappan River; (ii) Black River; and (iii) Baie du Vin River.

[**Note**: The lower horizontal lines indicate the "safe" concentrations recommended in the Canadian Freshwater Quality Guidelines; the upper lines indicate the lethal concentration at which fish will start to die.]

[Graphs constructed from data collected by MREAC.]

Figure 25


(i)
Lead (Pb): (Site #19)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Lead (Pb): (Site #20)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

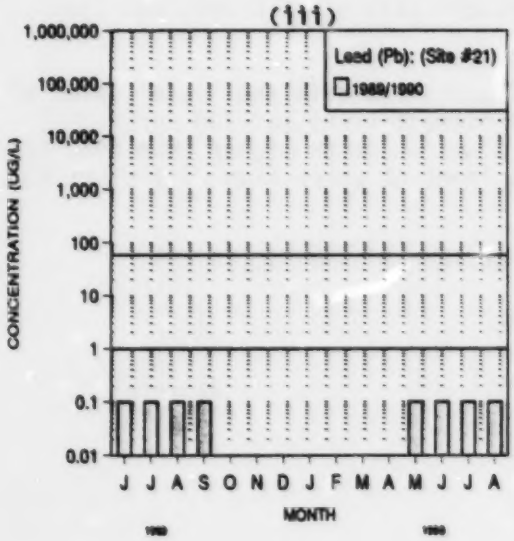
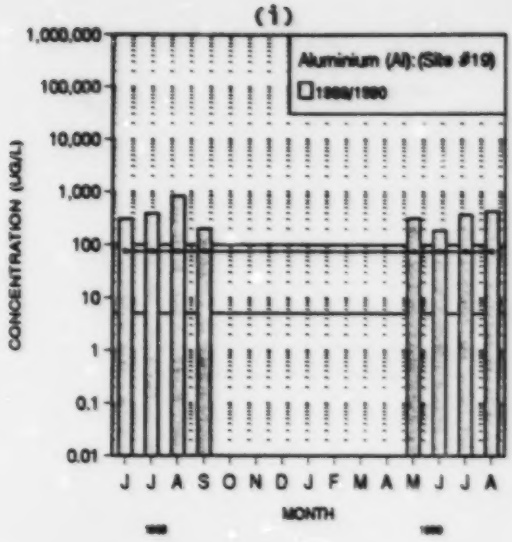

(iii)
Lead (Pb): (Site #21)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

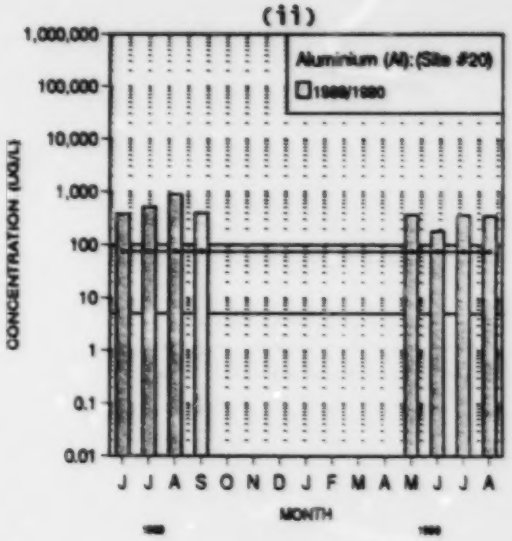
Figure 26. Concentrations of aluminum in monthly samples collected from Group III Sites: (i) Nappan River; (ii) Black River; and (iii) Baie du Vin River.

[**Note**: The lowest lines at (5 µg/L) indicate the 'safe' level of aluminum at pH below 6.5; the highest lines (at 100 µg/L) indicate the 'safe' level of aluminum at pH higher than 6.5. The line at 75 µg/L indicates the level at which fish will start to die at a pH below 6.5.]

[Graph constructed from data collected by MREAC.]

Figure 26


(i)
Aluminium (Al): (Site #19)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Aluminium (Al): (Site #20)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

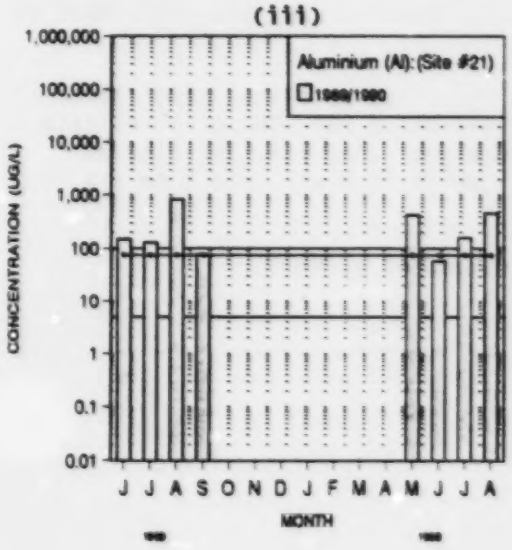
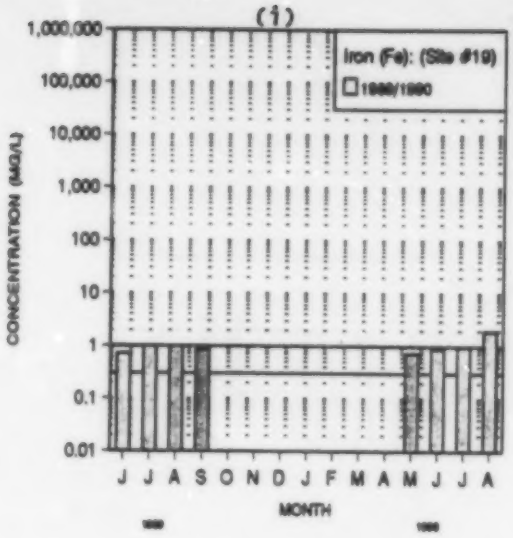

(iii)
Aluminium (Al): (Site #21)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

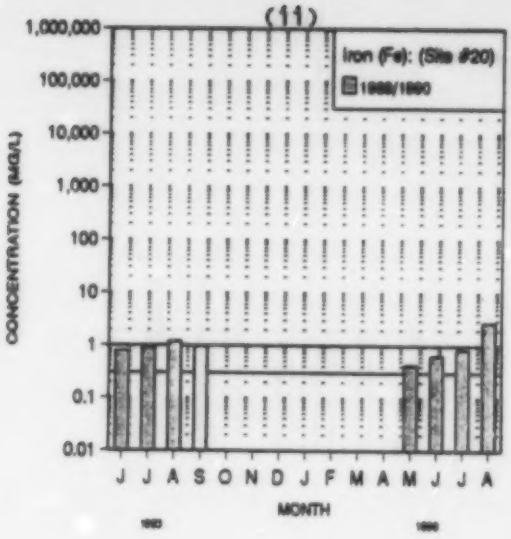
Figure 27. Concentrations of iron in monthly samples collected from Group III Sites: (i) Nappan River; (ii) Black River; and (iii) Baie du Vin River.

[Note: The lowest lines at (5 µg/L) indicate the 'safe' level of iron at pH below 6.5; the highest lines (at 100 µg/L) indicate the 'safe' level of iron at pH higher than 6.5. The line at 75 µg/L indicates the level at which fish will start to die at a pH below 6.5.]

[Graph constructed from data collected by MREAC.]

Figure 27


(i)
Iron (Fe): (Site #19)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (MG/L)
J J A S O N D J F M A M J J A
MONTH


(ii)
Iron (Fe): (Site #20)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (MG/L)
J J A S O N D J F M A M J J A
MONTH

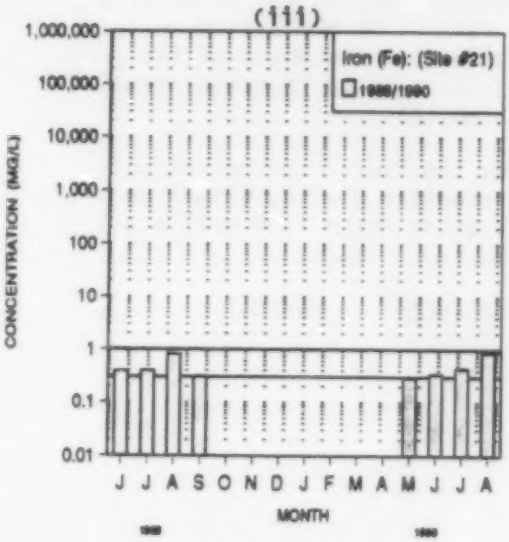
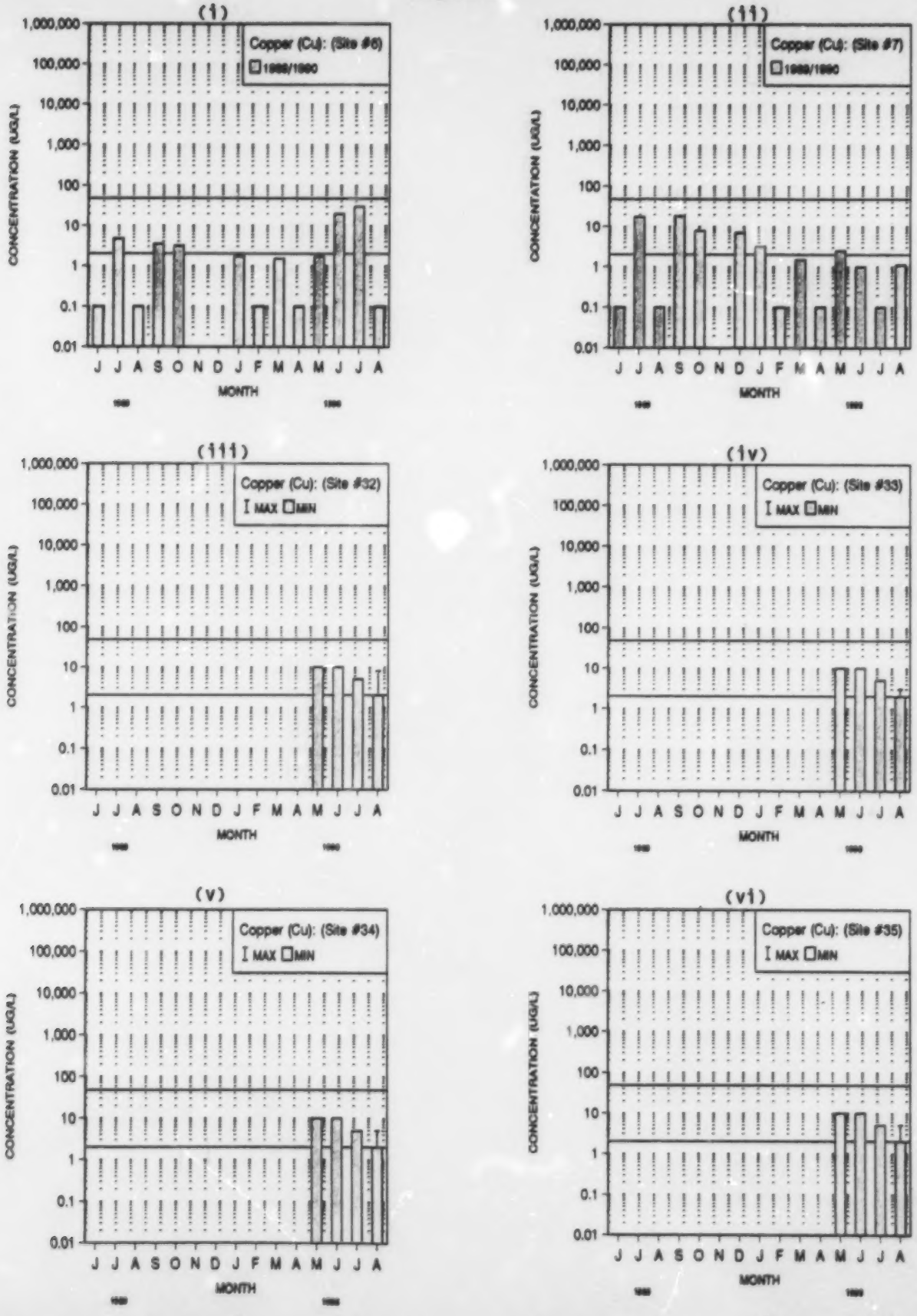

(iii)
Iron (Fe): (Site #21)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (MG/L)
J J A S O N D J F M A M J J A
MONTH

Figure 28. Concentrations of copper in monthly samples collected from Group IV sites: (i) Enclosure Park; (ii) Newcastle; (iii-iv) sites along a transect across the mouth of the Northwest Miramichi; (vii-x) sites along a transect across the mouth of the Main Southwest Miramichi.

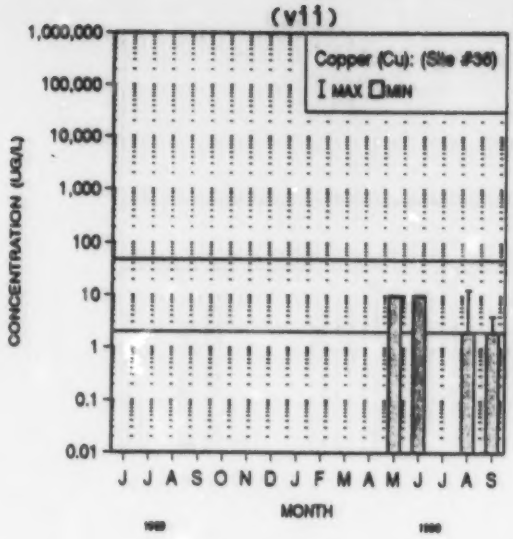
[Note: The lower line indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines: the upper line indicates the level above which fish will start to die.]

[Graph constructed from data collected by MREAC.]

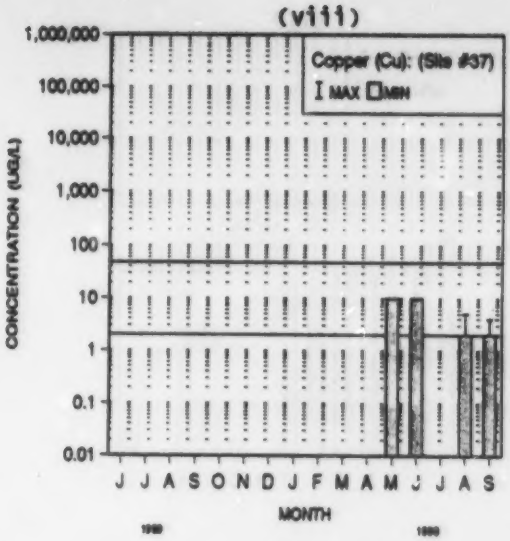
Figure 28


(i)
Copper (Cu): (Site #6)
1989/1990
(ii)
Copper (Cu): (Site #7)
1989/1990
(iii)
Copper (Cu): (Site #32)
MAX MIN
(iv)
Copper (Cu): (Site #33)
MAX MIN
(v)
Copper (Cu): (Site #34)
MAX MIN
(vi)
Copper (Cu): (Site #35)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

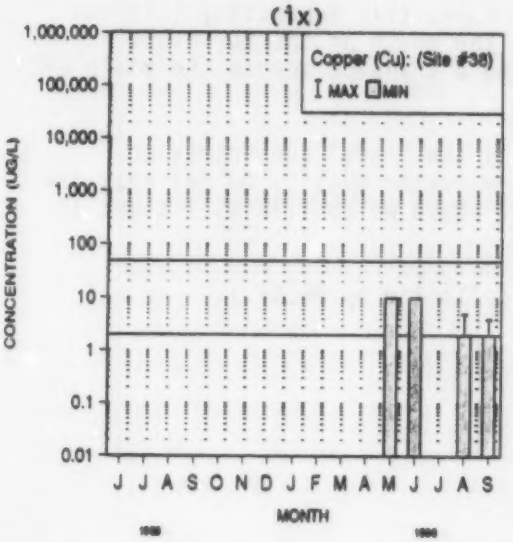
(vii)


Copper (Cu): (Site #36)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(viii)


Copper (Cu): (Site #37)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(ix)


Copper (Cu): (Site #38)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(x)

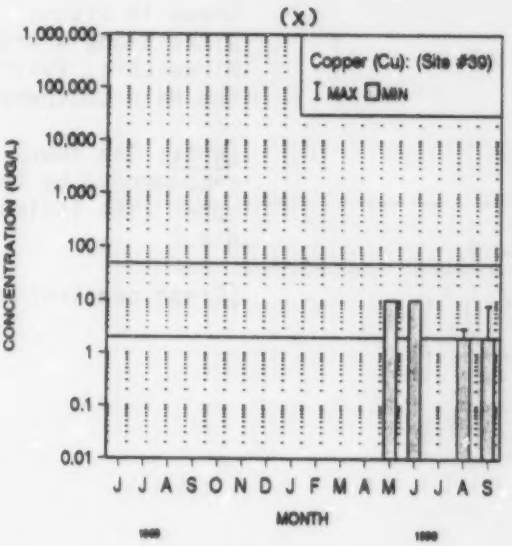
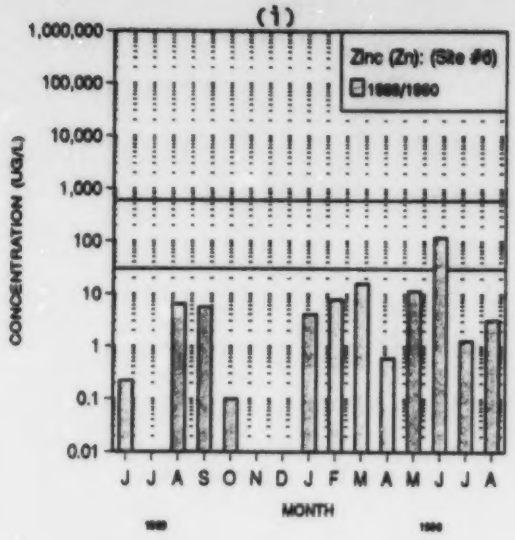

Copper (Cu): (Site #39)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

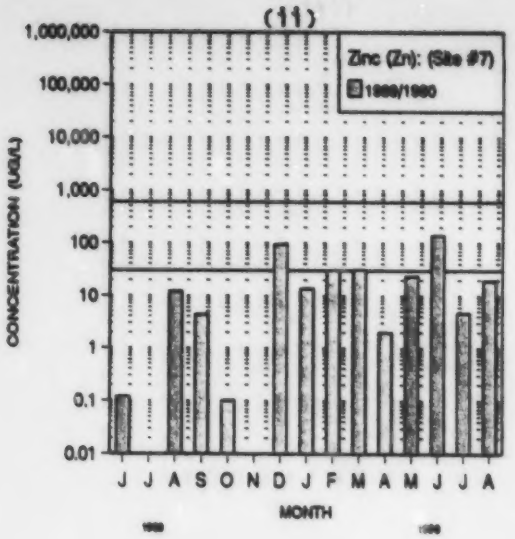
Figure 29. Concentrations of zinc in monthly samples collected from Group IV sites: (i) Enclosure Park; (ii) Newcastle; (iii-iv) sites along a transect across the mouth of the Northwest Miramichi;; (vii-x) sites along a transect across the mouth of the Main Southwest Miramichi.

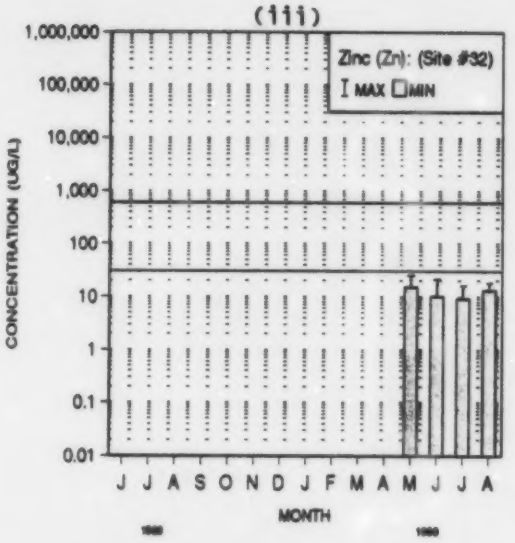
[**Note**: The lower line indicates the "safe" concentration recommended by the Canadian Freshwater quality Guidelines: the upper line indicates the level above wnich fish will start to die.]

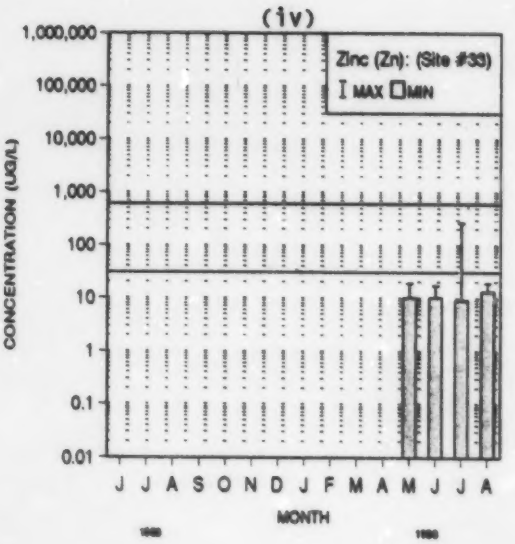
[Graph constructed from data collected by MREAC.]

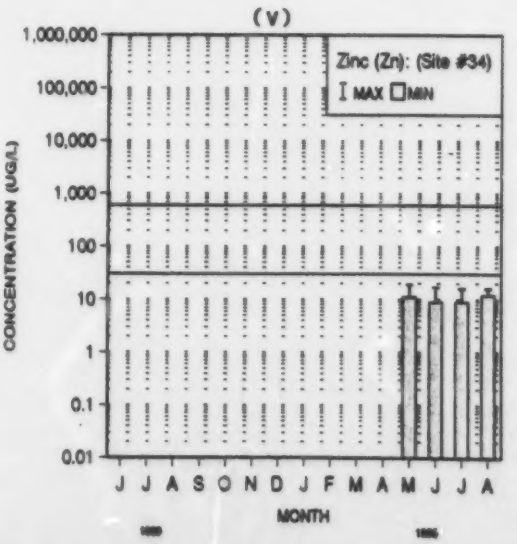
Figure 29

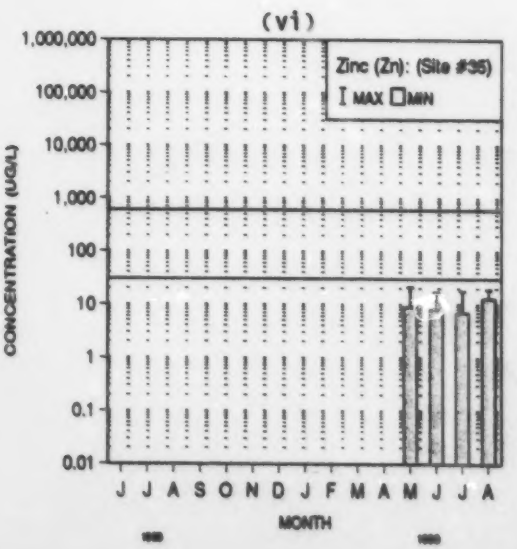

(i)
Zinc (Zn): (Site #6)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH


(ii)
Zinc (Zn): (Site #7)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

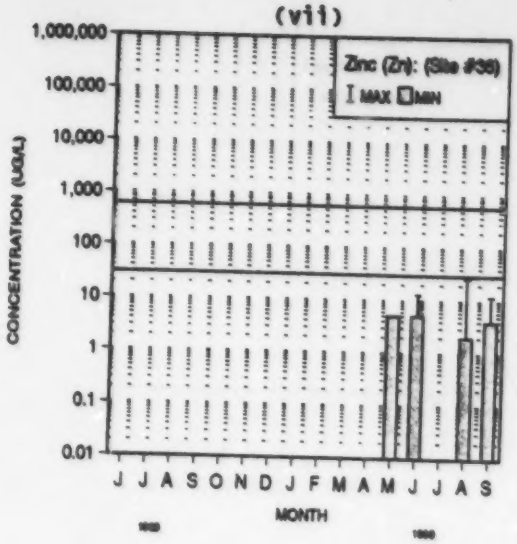

(iii)
Zinc (Zn): (Site #32)
MAX MIN
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH


(iv)
Zinc (Zn): (Site #33)
MAX MIN
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

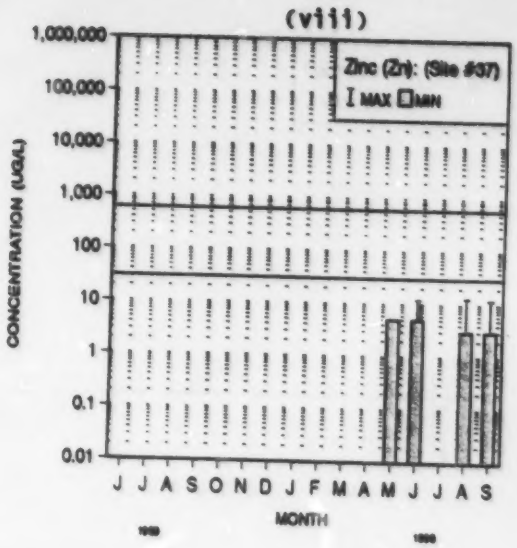

(v)
Zinc (Zn): (Site #34)
MAX MIN
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH


(vi)
Zinc (Zn): (Site #35)
MAX MIN
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
CONCENTRATION (UG/L)
J J A S O N D J F M A M J J A
MONTH

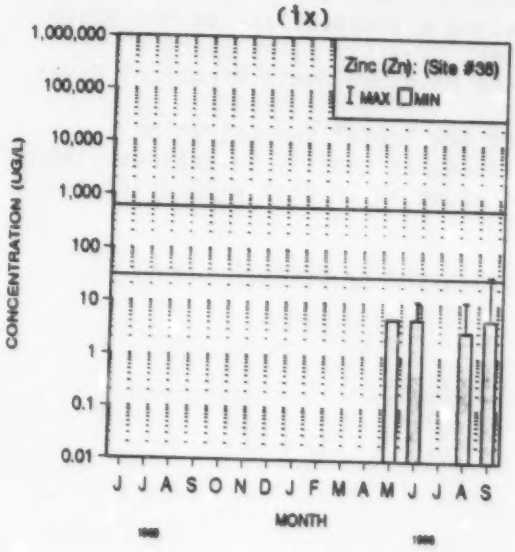
(vii)


Zinc (Zn): (Site #36)
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(viii)


Zinc (Zn): (Site #37)
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(ix)


Zinc (Zn): (Site #38)
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(x)

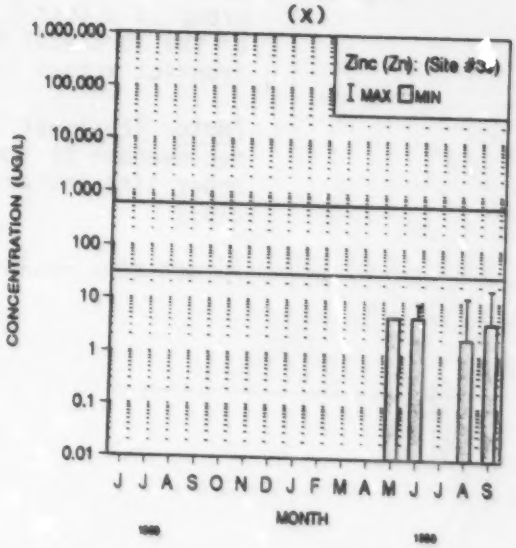
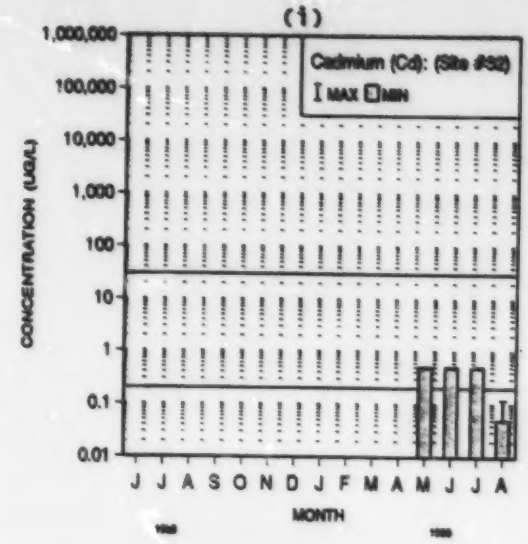

Zinc (Zn): (Site #3
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

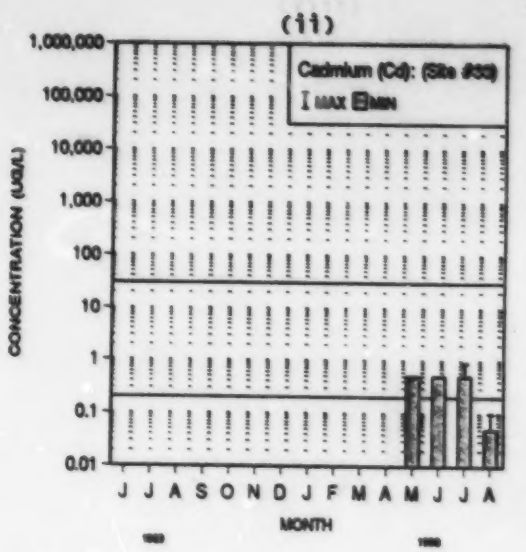
Figure 30. Concentrations of cadmium in monthly samples collected from Group IV sites: (i-iv) sites along a transect across the mouth of the Northwest Miramichi River; (v-viii) sites along a transect across the mouth of the Main Southwest Miramichi River.

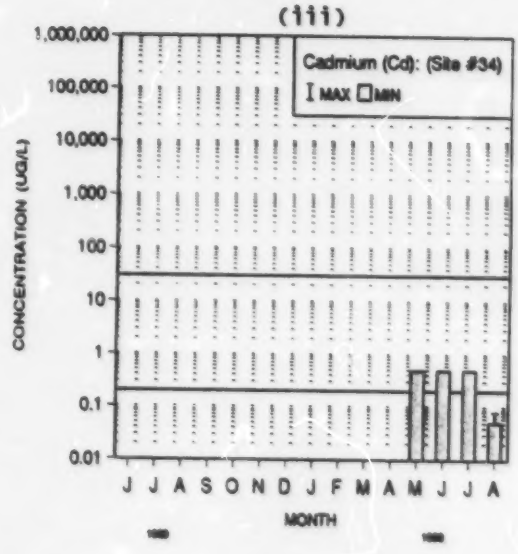
[**Note**: The lower line indicates the "safe" concentration recommended by the Canadian Freshwater quality Guidelines: the upper line indicates the level above which fish will start to die.]

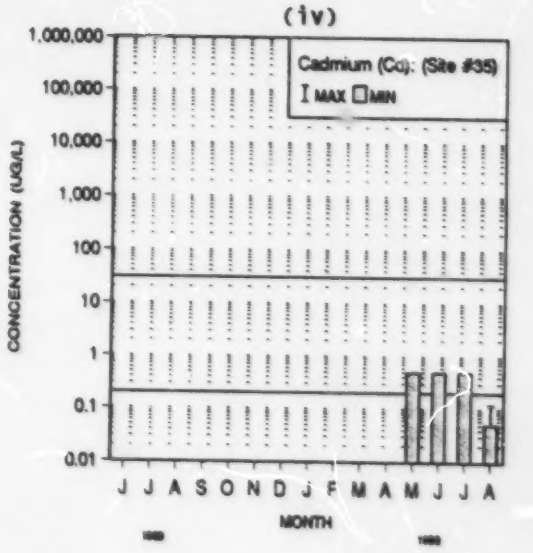
[Graph constructed from data collected by MREAC.]

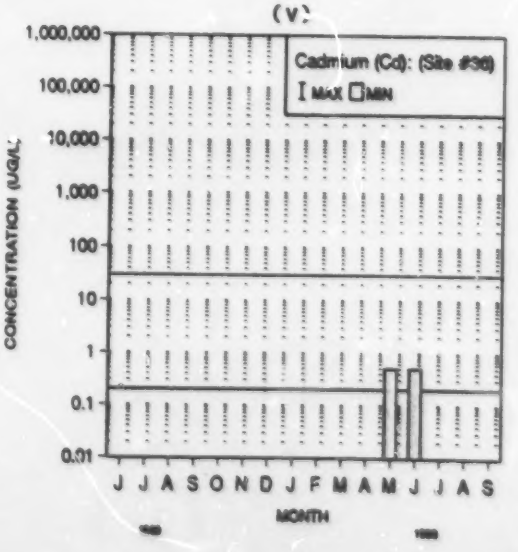
Figure 30

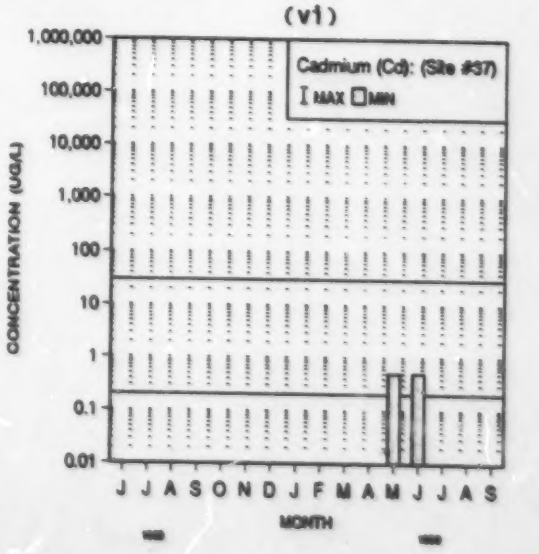

(i)
Cadmium (Cd): (Site #32)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Cadmium (Cd): (Site #33)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

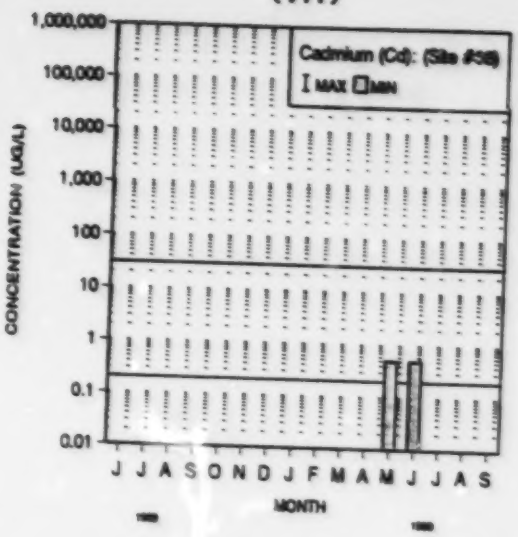

(iii)
Cadmium (Cd): (Site #34)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Cadmium (Cd): (Site #35)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(v)
Cadmium (Cd): (Site #36)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH


(vi)
Cadmium (Cd): (Site #37)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(vii)


Cadmium (Cd): (Site #58)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(viii)

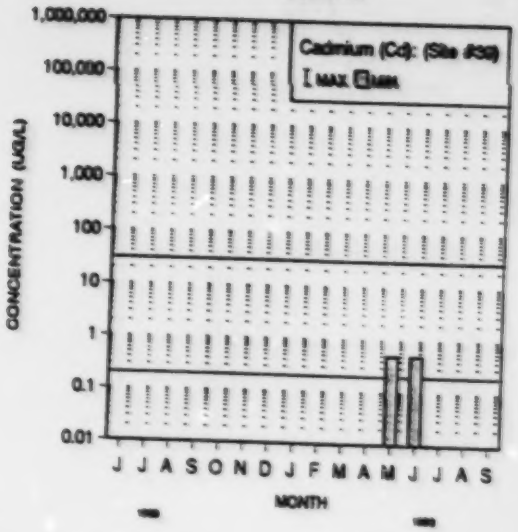
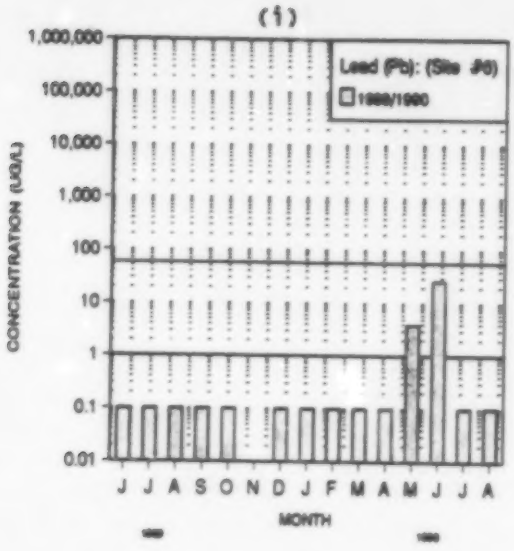

Cadmium (Cd): (Site #59)
I MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

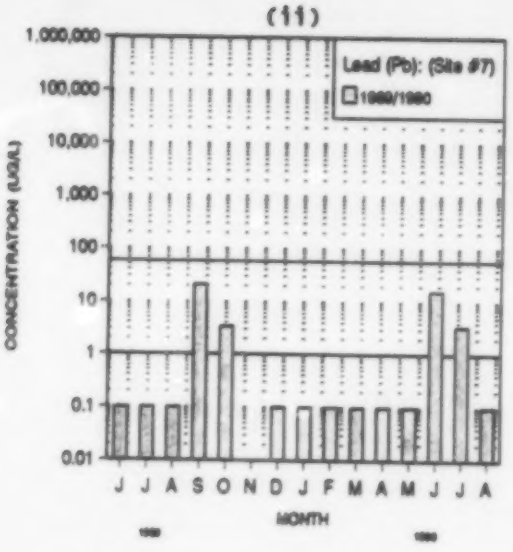
Figure 31. Concentrations of lead in monthly samples collected from Group IV sites: (i) Enclosure Park; (ii) Newcastle; (iii-iv) sites along a transect across the mouth of the Northwest Miramichi; (vii-x) sites along a transect across the mouth of the Main Southwest Miramichi.

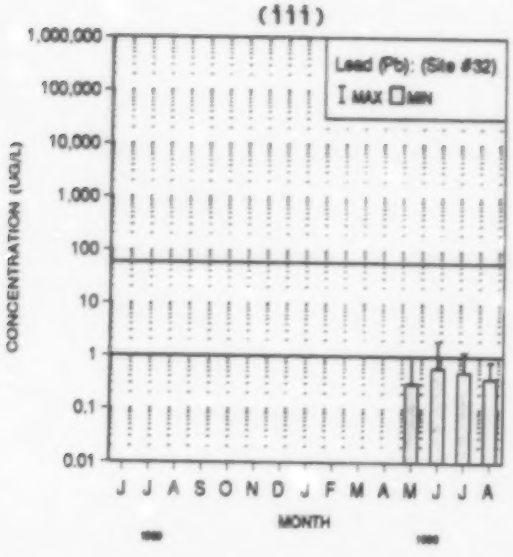
[**Note**: The lower line indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines: the upper line indicates the level above which fish will start to die.]

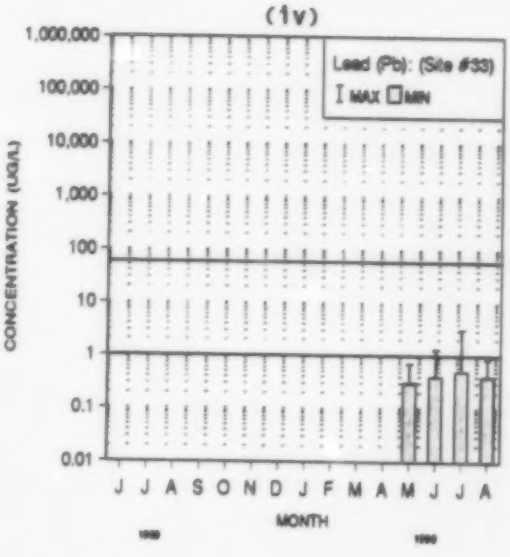
[Graph constructed from data collected by MREAC.]

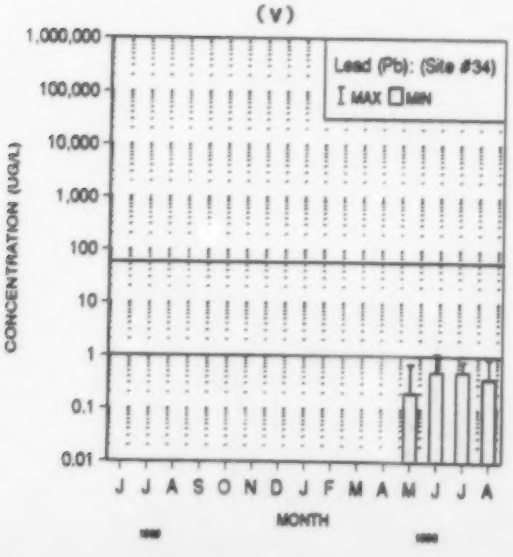
Figure 31

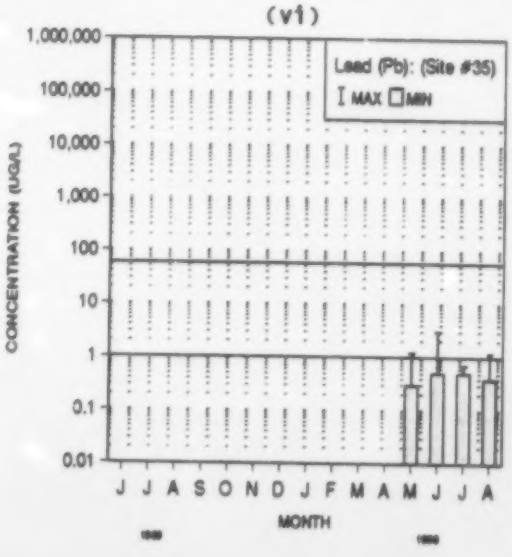

(i)
Lead (Pb): (Site #6)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Lead (Pb): (Site #7)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

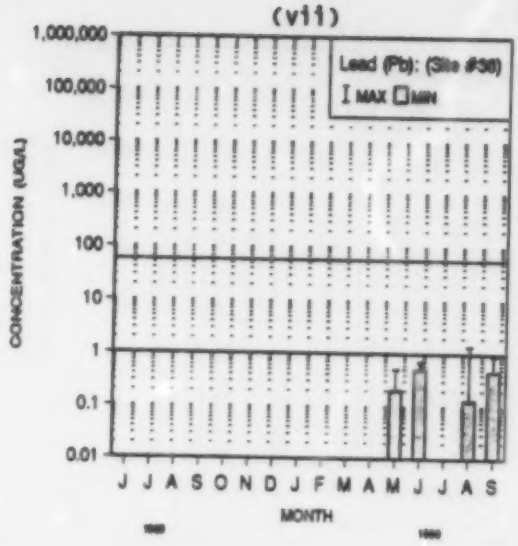

(iii)
Lead (Pb): (Site #32)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Lead (Pb): (Site #33)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

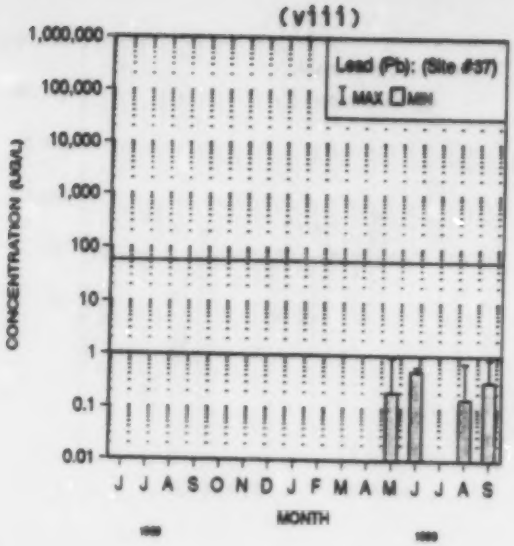

(v)
Lead (Pb): (Site #34)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(vi)
Lead (Pb): (Site #35)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

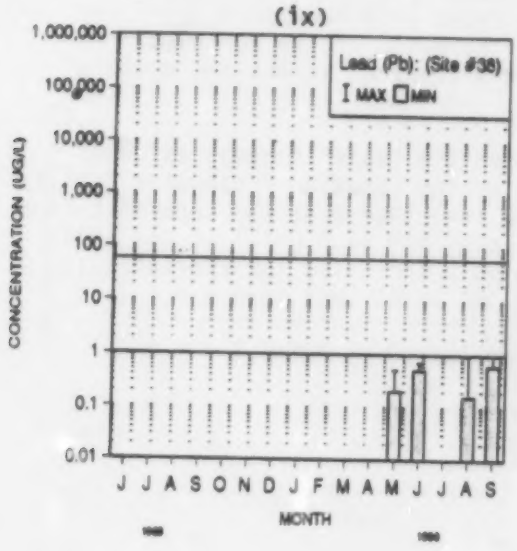
(vii)


Lead (Pb): (Site #36)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(viii)


Lead (Pb): (Site #37)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(ix)


Lead (Pb): (Site #38)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(x)

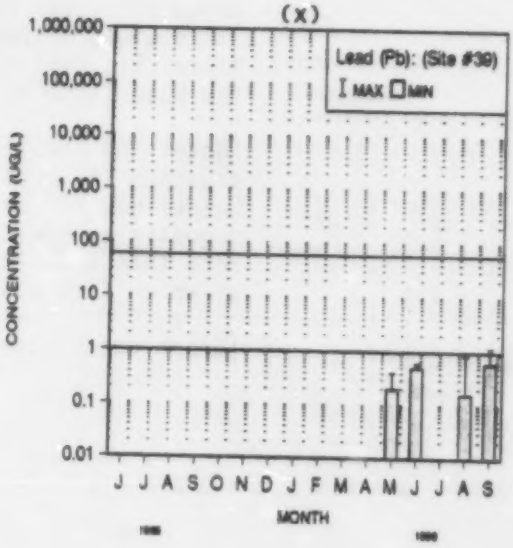
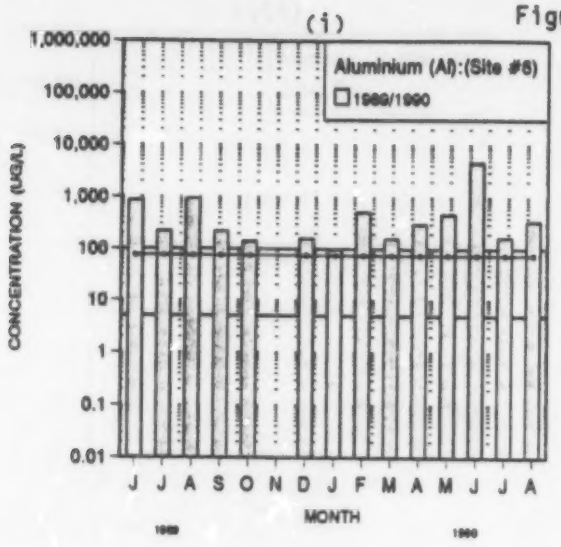

Lead (Pb): (Site #39)
I MAX ☐MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

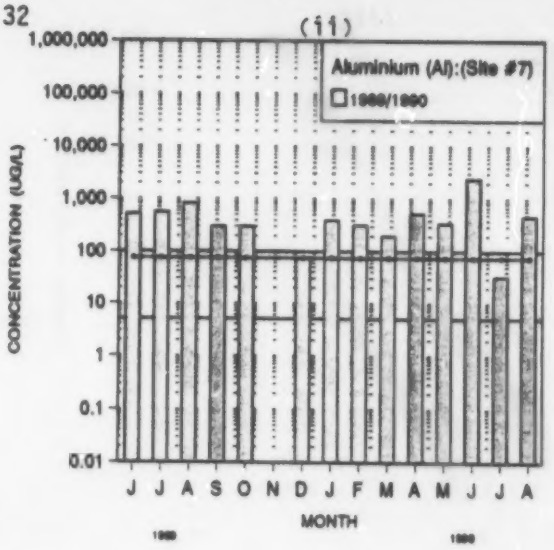
Figure 32. Concentrations of aluminum in monthly samples collected from Group IV sites: (i) Enclosure Park; (ii) Newcastle; (iii-iv) sites along a transect across the mouth of the Northwest Miramichi; (vii-x) sites along a transect across the mouth of the Main Southwest Miramichi.

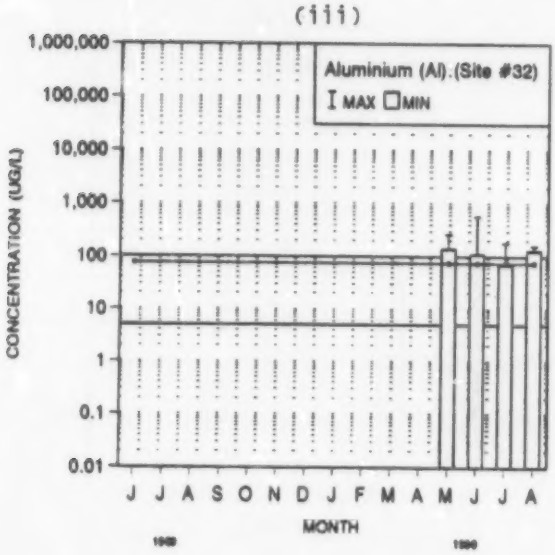
[**Note**: The lowest line indicates the "safe" concentration of aluminum (5 μg/L) recommended by the Canadian Freshwater Quality Guidelines for water with a pH less than 6.5; the uppermost line suggests a safe concration of aluminum (100 μg/L) if the pH is more than 6.5. The line at 75 μg/L indicates the concentration at which fish start to die if the pH is less than 6.5.)

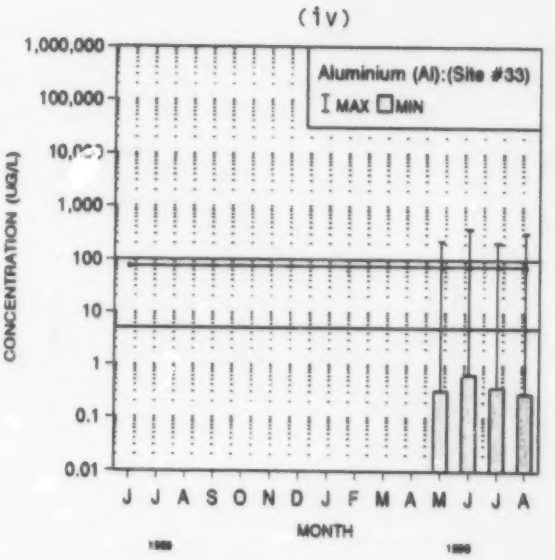
[Graph constructed from data collected by MREAC.]

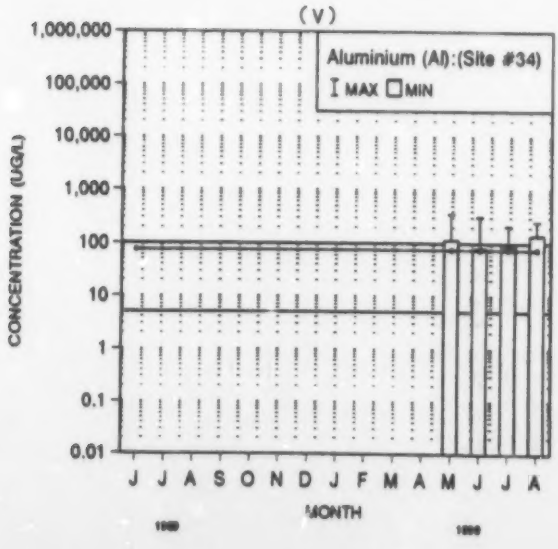
Figure 32

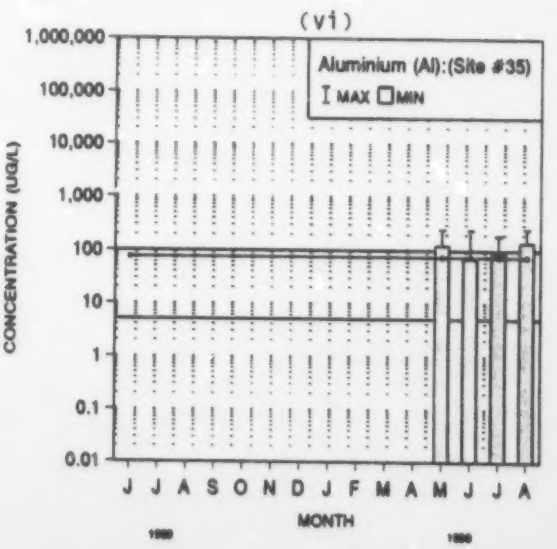

(i)
Aluminium (Al):(Site #6)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(ii)
Aluminium (Al):(Site #7)
1989/1990
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

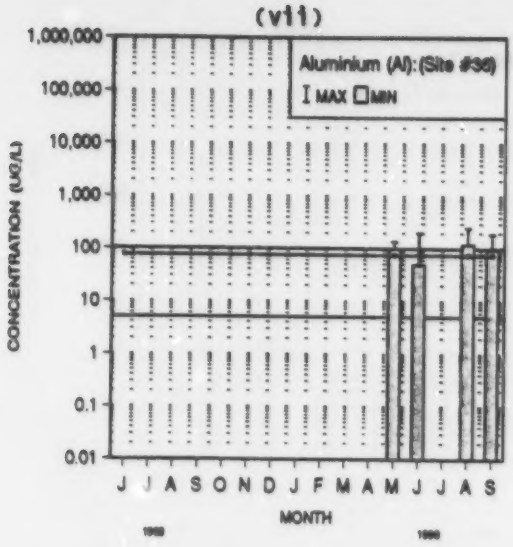

(iii)
Aluminium (Al).(Site #32)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(iv)
Aluminium (Al):(Site #33)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

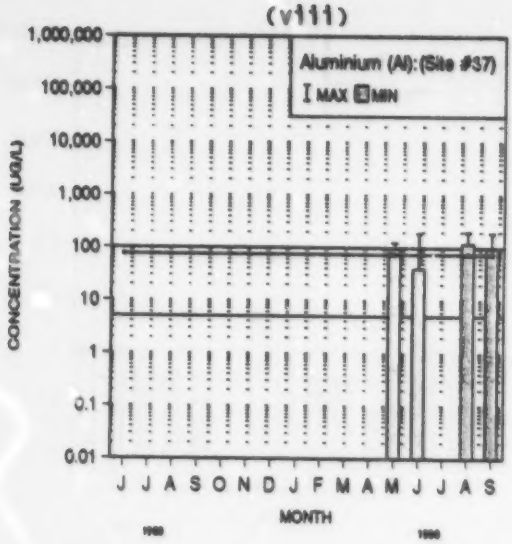

(v)
Aluminium (Al):(Site #34)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH


(vi)
Aluminium (Al):(Site #35)
MAX MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

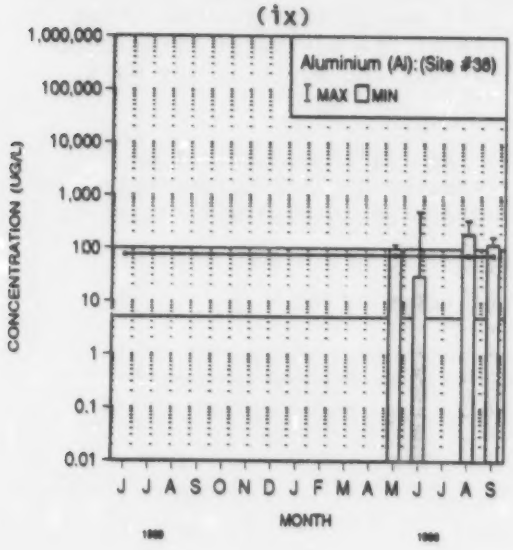
(vii)


Aluminium (Al): (Site #36)
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(viii)


Aluminium (Al): (Site #37)
I MAX ▣MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(ix)


Aluminium (Al): (Site #38)
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(x)

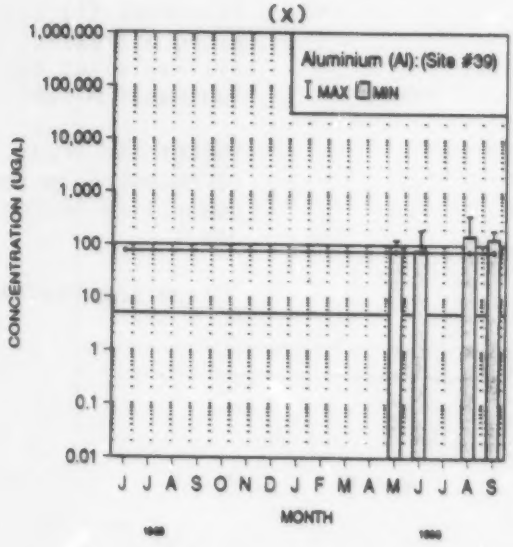
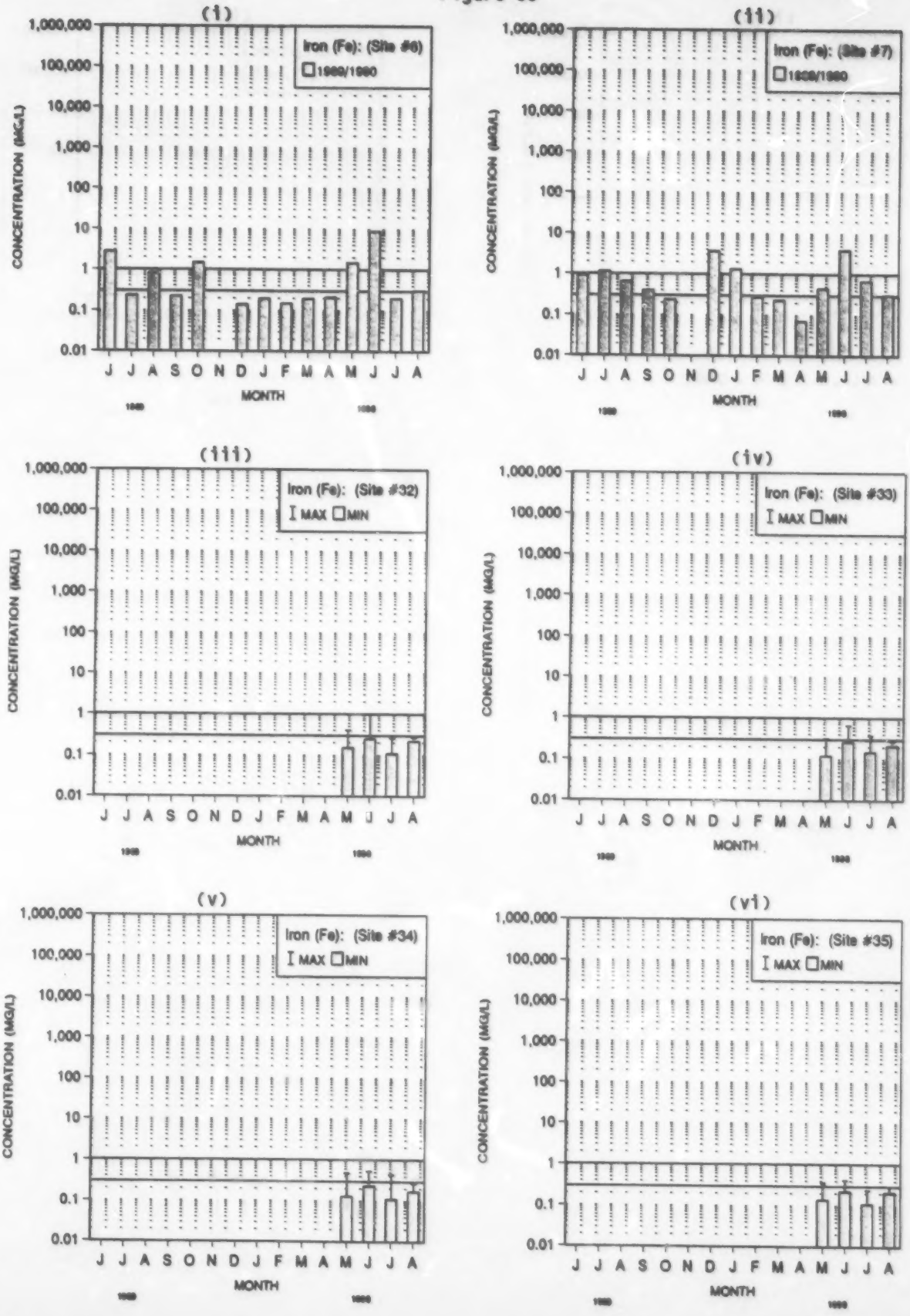

Aluminium (Al): (Site #39)
I MAX □MIN
CONCENTRATION (UG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

Figure 33. Concentrations of iron in monthly samples collected from Group IV sites: (i) Enclosure Park; (ii) Newcastle; (iii-iv) sites along a transect across the mouth of the Northwest Miramichi; (vii-x) sites along a transect across the mouth of the Main Southwest Miramichi.

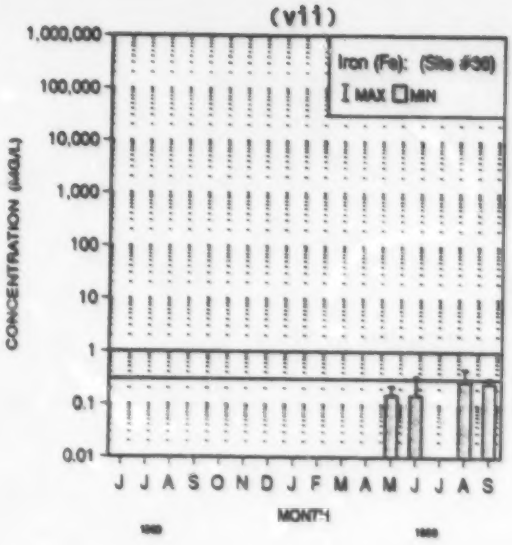
[Note: The lower line indicates the "safe" concentration recommended by the Canadian Freshwater Quality Guidelines: the upper line indicates the level above which fish will start to die.]

[Graph constructed from data collected by MREAC.]

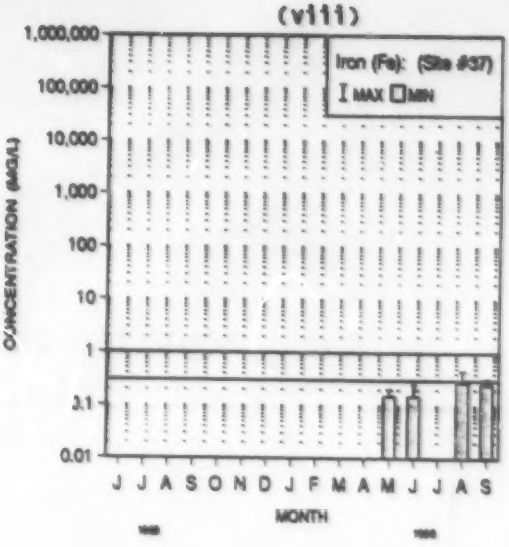
Figure 33


(i)
Iron (Fe): (Site #6)
1979/1980
(ii)
Iron (Fe): (Site #7)
(iii)
Iron (Fe): (Site #32)
I MAX MIN
(iv)
Iron (Fe): (Site #33)
I MAX MIN
(v)
Iron (Fe): (Site #34)
I MAX MIN
(vi)
Iron (Fe): (Site #35)
I MAX MIN
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A
MONTH

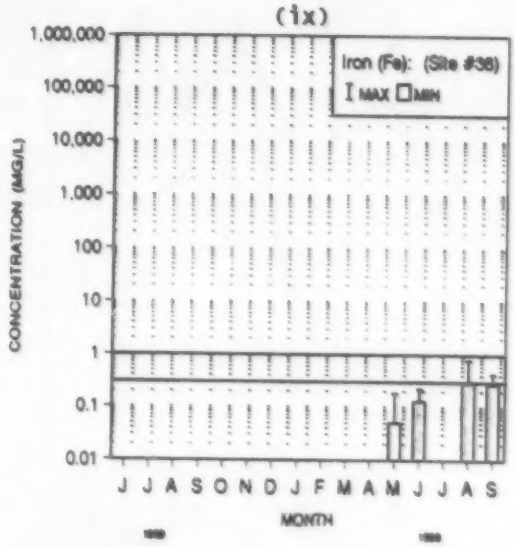
(vii)


Iron (Fe): (Site #36)
I MAX □MIN
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(viii)


Iron (Fe): (Site #37)
I MAX □MIN
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(ix)


Iron (Fe): (Site #38)
I MAX □MIN
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

(x)

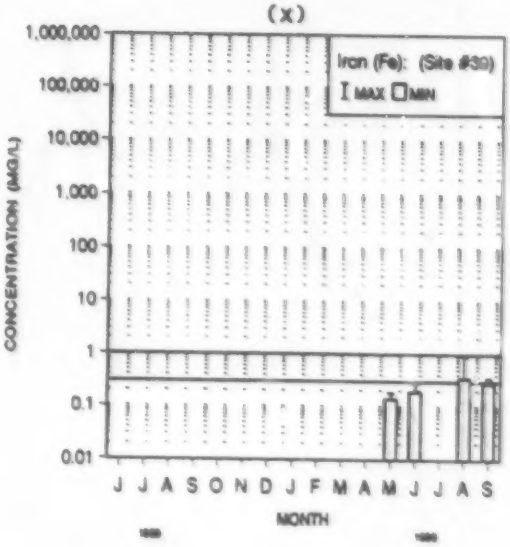
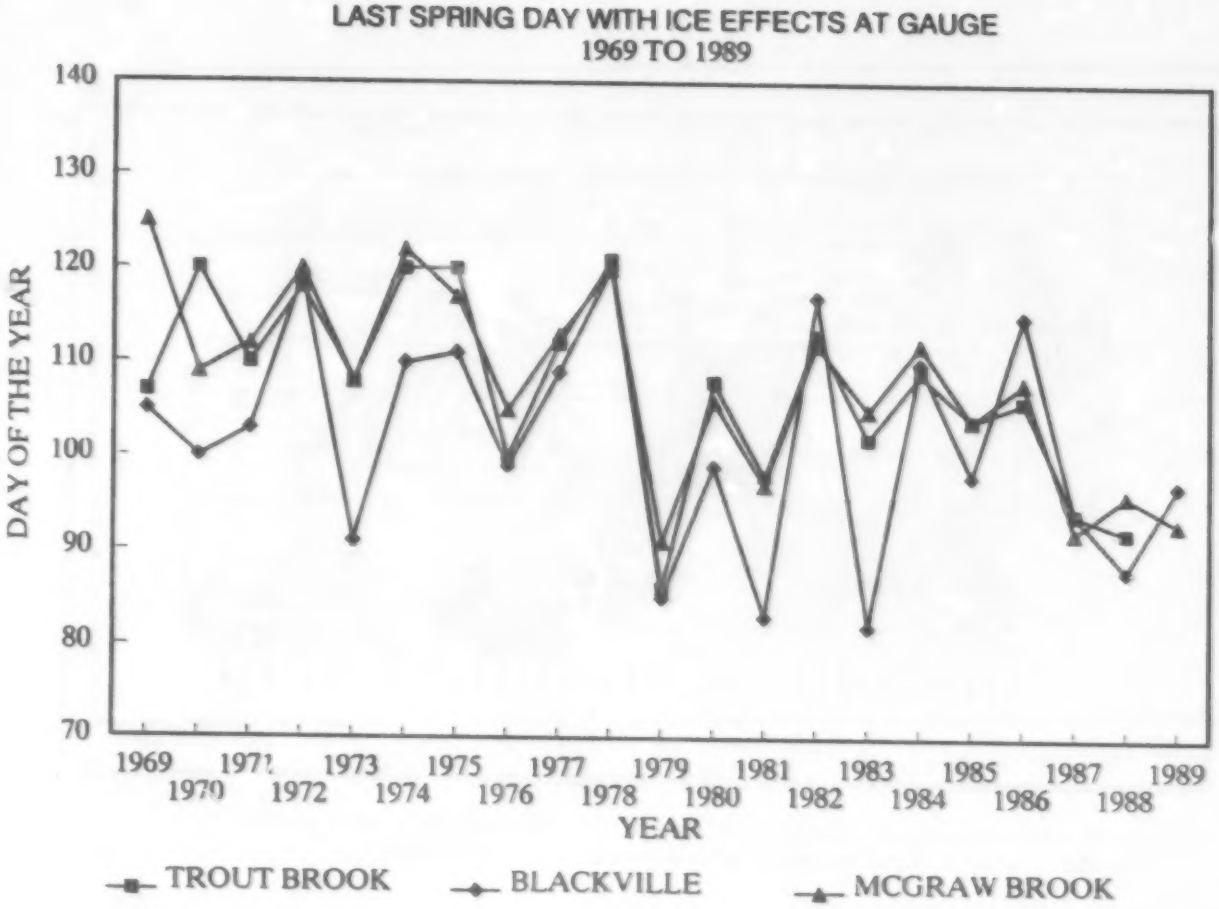

Iron (Fe): (Site #39)
I MAX □MIN
CONCENTRATION (MG/L)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
J J A S O N D J F M A M J J A S
MONTH

Figure 34


LAST SPRING DAY WITH ICE EFFECTS AT GAUGE
1969 TO 1989
DAY OF THE YEAR
140
130
120
110
100
90
80
70
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
YEAR
TROUT BROOK
BLACKVILLE
MCGRAW BROOK

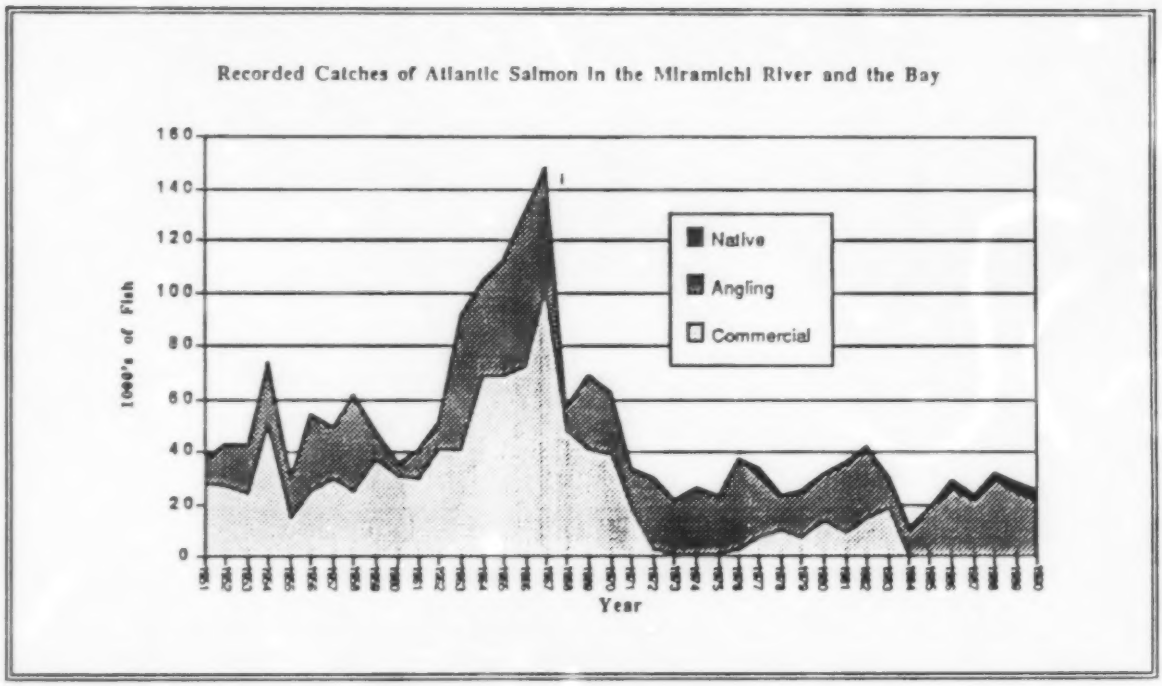


Figure 35. *Recorded catches of salmon in all the fisheries - Miramichi River and Bay, 1951-1990 (includes commercial, bycatch, recreational, and native). (Moore et al., 1991).*

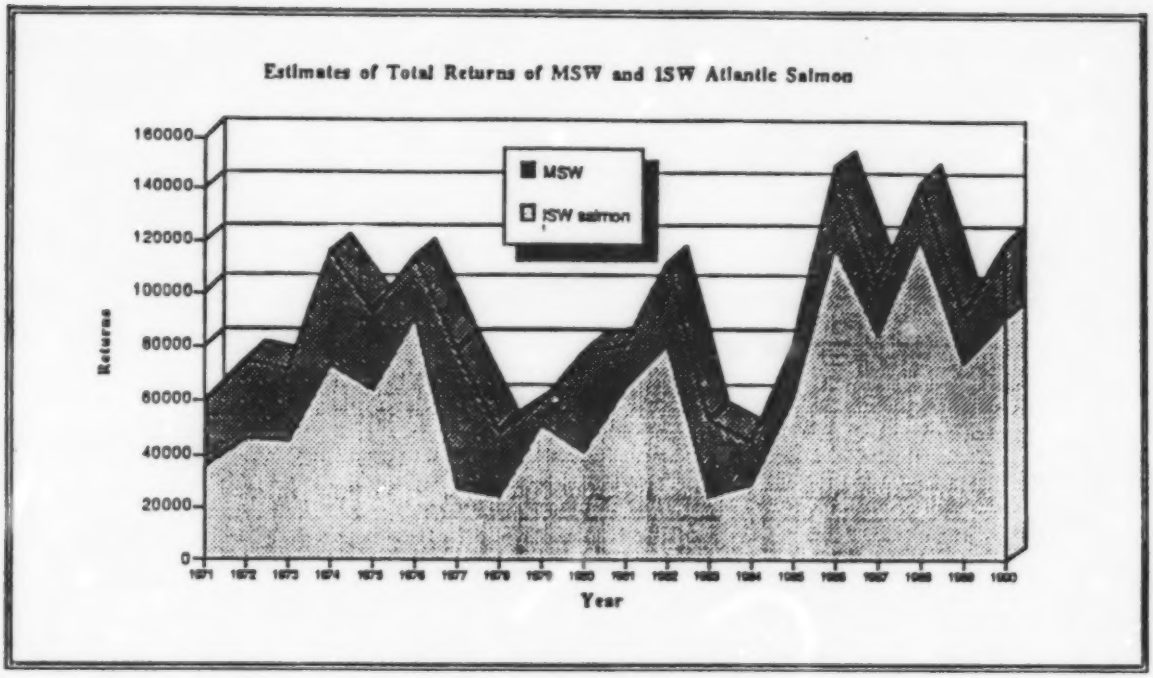


Figure 36.- *Estimates of total returns of MSW and 1SW salmon in the Miramichi River, 1971-1990) (Moore et al., 1991).*

Table I. Lethal concentrations of various metals

Metal	Lethal concentration	Target species	Reference
Copper	48 µg/L	juvenile Atlantic salmon	Sprague, 1964
Zinc	600 µg/L	juvenile Atlantic salmon	Sprague, 1964
Cadmium	30 µg/L (with 105 µg/L zinc)	juvenile Chinook salmon	In: McKee & Wolf, 1963
Mercury	8 µg/L 15 µg/L	Stickleback Various fish e.g. *Fundulus*, *Brachydania* and *Oryzias*	In: McKee & Wolf, 1963 In: Furness & Rainbow, 1990
Iron	1-2 mg/L	Trout, pike, and tench	In: McKee & Wolf, 1963
Lead	58 µg/L	Brook trout	Holcombe *et al*. 1976

Table II. Sampling periods and numbers of water samples analysed for different metals by Environment Canada from 1961 to 1977 at various sites* (A-V) within the Miramichi River system.

Sites*	Period Samples	Number of water samples analysed for each of the metals shown					
		Cu	Zn	Fe	Cd	Hg	Pb
A	May'69 - Sept.'77	39	39	23	18	8	33
B	June'69 - Aug.'76	31	31	28	23	12	28
C	June'69 - Aug.'76	30	29	28	23	12	27
D	Oct'70 - Sept.'77	17	18	16	13	7	16
E	July'65' - Sept.'77	57	54	54	15	8	23
F	June'69 - Sept.'77	38	38	20	17	7	31
G	Nov.'70 - Sept.'74	11	11	13	10	4	11
H	Oct.'70 - Sept.'77	16	16	14	13	10	15
I	July'65 - Sept.'77	37	35	30	14	9	22
J	July'65 - Sept.'77	35	34	28	12	9	22
K	June'62 - Feb.'74	71	74	30	18	12	28
L	Oct.'70 - Sept.'76	14	14	14	12	9	13
M	June'65 - Feb.'74	36	37	25	19	11	25
N	June'66 - Aug.'76	48	49	37	9	9	36
O	June'63 - Aug.'76	80	86	48	27	20	47
P	June'66 - Aug.'76	83	81	46	9	6	46
Q	July'68 - Oct.'73	32	32	19	15	8	19
R	July'68 - Oct.'73	28	28	16	11	6	16
S	July'70 - Sept.'73	29	28	24	2	1	23
T	Jan.'71 - Sept.'76	35	35	35	10	12	34
U	June'63 - Mar.'75	400	400	233	223	-	215
V	Oct.'74 - Sept.77	9	9	8	9	8	9

*These sites are organized into different groupings and shown in Table IIB.

Table III. Monthly average of toxic units for mining pollution of the Northwest Miramichi River at Curventon. A value of 1.0 toxic units is just lethal for fish at summer temperature.

Month	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	All Years
Jan.	–	.20	.77	.85	.54	.82	.70	1.3	.43	.46	.40	.39	.08	.58
Feb.	–	.39	.53	.70	.48	.69	.92	1.2	.50	.44	1.21	.37	.08	.63
Mar.	–	.31	.63	.44	.59	.82	1.70	1.1	.58	.32	.25	.15	.08	.58
Apr.	–	.36	.59	.95	.82	1.00	1.10	.77	.87	1.22	.37	.39	.08	.71
May	–	.36	.74	1.20	1.00	.57	.68	1.1	.32	.70	.64	27	.11	.64
June	.88	.40	.33	.54	.43	.32	.28	.38	.18	.20	.15	.10	.10	.33
July	.63	.14	.44	.38	.24	.28	.21	.18	.18	.23	.11	.01	.11	.24
Aug.	.22	.11	.56	.61	.29	.42	.14	.08	.12	.45	.13	.06	.10	.25
Sept.	.50	.14	.37	.81	.32	.34	.14	.37	.20	.64	.23	.05	.08	.32
Oct.	1.80	.28	.26	.52	.45	.53	.26	.38	.39	.14	.26	.14	.09	.42
Nov.	1.00	.25	.49	.74	.63	.62	.46	.33	.33	.69	.11	.07	.09	.45
Dec.	.41	.30	.57	.57	1.20	.44	.89	.32	.36	.36	.15	.09	.11	.45
Year	.77	.27	.52	.69	.58	.57	.62	.62	.37	.49	.33	.17	.09	.47

Table IV. Miramichi River: Surface Water and Benthic Invertebrate (*) Sample Site Descriptions.

1*	North Branch Southwest Miramichi River. Irving gate in Juniper Station across from the railway tracks. Specifically, taking the right hand road to the second cottage prior to the gate. Samples were removed approximately one meter from river bank.
2*	Southwest Miramichi River. Samples were removed from the river at Bloomfield Ridge near the northeast bank directly down from the dirt road.
3*	Southwest Miramichi River. Samples were taken near the river bank at the Boiestown DNR facility off highway 8. Specifically, at the end of the gravel road and off the beach.
4*	Southwest Miramichi River. This site is located on the south side of the Doaktown highway 8 bridge. Specifically, on the west side 10 m upriver of the bridge and 1 m out into the river.
5*	Southwest Miramichi River. The east side of the highway 118 bridge on the upstream side at Blackville.
6*	South Miramichi River. Near the Enclosure Provincial Park (Newcastle), upriver of the railway bridge at the beach of a cottage. Specifically, 2 m from the end of the stairway.
7*	Northwest Miramichi River. Samples were removed from the upstream side of the highway 8 bridge on the shore of the river just south of Newcastle.
8*	Northwest Miramichi River. Samples were removed from the river at Wayerton on the west side of the highway 430 bridge. Specifically, at the downstream corner of the gravel beach.
9*	Little Southwest Miramichi River. Sampled at Lyttleton on the downstream, northern side of the highway bridge; approximately 10 m from the bridge.
10	South Branch Southwest Miramichi River. Sampled on the north, upstream side (by the church), of the Juniper highway bridge.
11	Southwest Miramichi River. Samples taken off highway 107 at the roadside park near Deersdale.
12	Southwest Miramichi River. Ludlow bridge, on the northern shore of the upriver side.
13	Southwest Miramichi River. Nelsons Hollow, samples were taken across from the covered bridge near the confluence of Mill Brook.
14	Southwest Miramichi River. Near Upper Blackville, on the upstream Cains River side of the Cains River road bridge.

Table IV continued

15 Cains River. Approximately, 4 km upriver of its confluence with the Southwest Miramichi River.

16 Bartholomew River. Near Blackville prior to the river's entry under the highway 8 bridge.

17 Southwest Miramichi River. Quarryville bridge (route 188) sampled on the Quarryville side upriver of the bridge.

18 Barnaby River. Sampled near the north shore of the downriver side of the highway 188 bridge.

19 Nappan River. Sampled approximately 10 m upstream of the highway 11 bridge.

20 Black River. Sampled approximately 10 m upstream of the highway 11 bridge.

21* Baie du Vin River. Sampled upriver of the highway 11 bridge.

22 Sevogle River. Sampled just upstream of its confluence with the Northwest Miramichi River.

23 Renous River. The river was sampled near the northern shore of the ruined highway 8 bridge.

24 Dungarvon River. Sampled just prior to the confluence of the Dungarvon and Renous Rivers.

25 Southwest Miramichi River. Sampled across from the fishing lodge near Burnt Hill Mine.

26 Taxis River. Sampled downriver of the highway 625 bridge.

27 Southwest Miramichi River. Sampled on the same side and 20 m upriver of the Doaktown sewage lagoon discharge.

28 Southwest Miramichi River. Sampled midpoint and across from, the old (1989) downriver Doaktown site (site 4) and the upriver station above the sewage discharge (site 27).

29 Southwest Miramichi River. Sampled downriver and opposite of the 1989 Blackville station (site 5).

30 Northwest Miramichi River. Sampled near the southeast shore upriver of the highway 430 bridge. Specifically, 2 m from the gravel beach shore.

31 Tomogonops River. Downriver of the haul road bridge prior to the confluence with Northwest Miramichi River.

Table IV continued

32.35* Stations which sample the breadth of the Northwest Miramichi River at Newcastle which form a transect with site 7. Sampled at high, mid- and low-tides. With surface, mid-depth and bottom samples removed during each interval.

36.39* Stations which sample the breadth of the Southwest Miramichi River at Enclosure Provincial Park which form a transect with site 6. Sampled at high, mid- and low-tides. With surface, mid-depth and bottom samples removed during each interval.

40 Miramichi Estuary. Transect across the breadth of the estuary near Sheldrake Island.

41 Miramichi Estuary. Transect across the breadth of the estuary near Middle Island.

42 Miramichi Estuary. Transect across the breadth of the estuary near Chatham Bridge.

43 Miramichi Estuary. Transect across the breadth of the estuary near Morsey Bridge.

44 Miramichi Estuary. Transect across the breadth of Baie du Vin.

45 Miramichi Estuary. Transect across the breadth of the estuary inshore of Fox Island.

Water Chemical Parameters

The water samples were analyzed for the following metals, nutrients and general characteristics:

Metals: Aluminum; Cadmium; Copper; Iron; Lead; Manganese and Zinc.

Nutrients: Ammonium; Dissolved Organic Carbon; Nitrates; Nitrites and Total Kjeldahl Nitrogen and Phosphorus.

General Characteristics: Alkalinity; Calcium; Colour; Conductivity; Chloride; Dissolved Oxygen; Magnesium; pH; Potassium; Sodium; SO_4; Suspended Solids; Temperature; Total Dissolved Solids; Turbidity and Water Hardness.

Bacterial: Total and Faecal Coliform with Streptococcus sp. counts when required.

Table IV continued

Soil Analysis

The soil which made up the substrate of the estuary, both near the confluence of the Northwest and Southwest Miramichi Rivers and in the outer basin, were analyzed for the following parameters, some of which were: Ligands and other wood derived compounds; the metals Cadmium, Zinc. etc..

Benthic Invertebrate Communities

The insects and other invertebrates which inhabit the areas immediately around and underneath rivers and lakes during the majority of their lives are termed aquatic invertebrates. The invertebrates which were sampled at the indicated sites were removed from the bottom (therefore benthic) of the river as well as the rocks and plants which helped from the river bed.

Special Surveys

These surveys were undertaken in order to gain specific information or understanding. Included in this group were:

Burnt Hill Mine, in York County - Seepage and effluent discharges.
Taxis River, near Boiestown, Northumberland County - Bacterial Surveys.
Other Coliform and Point Source Surveys - Widespread.
Miramichi Estuary surveys, near pulp mill discharges. Undertaken with the participation of N.B. Environments, Industrial Programs Section.

Table V. MREAC study sites showing average pH and temperature readings and median DOC, and hardness values.

Group I:	Site #	Location	pH	DOC	Hardness	Temp.
	1	Juniper Station	6.8	8.0	14.1	9.6
	10	Juniper	6.7	6.1	12.8	10.0
	11	Deersdale	5.5	10.4	11.3	9.1
	25	Burnt Hill Mine	-	-	-	-
	2	Bloomfield Ridge	6.8	6.4	10.4	11.5
	26	Taxis River	7.0	5.6	16.9	11.5
	15	Cains River	7.2	5.9	18.3	11.5
Group IIA:	**Site #**	**Location**	**pH**	**DOC**	**Hardness**	**Temp.**
	3	Boiestown	6.9	9.5	12.0	11.0
	12	Ludlow	7.1	3.7	14.0	13.0
	13	Nelson's hollow	6.8	4.7	10.8	9.3
	27	Doaktown (upper)	6.5	5.8	9.5	11.5
	4	Doaktown Bridge	6.8	5.4	12.8	11.8
	28	Doaktown (across)	6.8	5.0	12.9	12.5
	14	Upper Blackville	6.8	5.3	12.7	12.0
	16	Bartholemew River	7.3	4.4	20.5	11.4
	5	Blackville	-	7.3	13.1	-
	29	Blackville (across)	7.0	4.2	15.0	12.0
	24	Dungarvon River	7.0	5.9	13.3	11.0
	23	Renous River	7.1	6.4	13.8	11.0
	17	Quarryville	7.0	9.9	17.3	12.3
	18	Barnaby River	7.0	14.8	20.8	12.6
Group IIB:	**Site #**	**Location**	**pH**	**DOC**	**Hardness**	**Temp.**
	30	Miners Bridge	7.1	4.6	15.1	9.7
	31	Tomogonops R.	-	0.2	91.8	-
	8	Wayerton Bridge	7.0	7.5	32.6	10.6
	9	Lyttleton Bridge	6.9	5.9	10.8	10.4
Group III:	**Site #**	**Location**	**pH**	**DOC**	**Hardness**	**Temp.**
	21	Riviere Baie du Vin	7.3	13.7	29.4	12.4
	20	Black River	6.6	26.1	61.2	12.4
	19	Nappan River	6.5	24.8	18.7	11.1
Group IV:	**Site #**	**Location**	**pH**	**DOC**	**Hardness**	**Temp.**
	6	Enclosure Park	6.9	9.0	199	12.6
	7	Newcastle	7.0	11.0	254	12.6
	32-35	Northwest, Mouth	7.0	7.6	130	-
	36.39	Southwest, Mouth	7.0	8.5	142	-

Table VI. pH Readings During Snowmelt Period 1990

Date	McGraw Brook	Stewart Brook	Breynton	Deersdale	Comments
April 7		6.62	6.3		
April 8			6.5		
April 9	6.7	6.50	6.7	6.5	Raining, ice starting to break out
April 10		6.30	6.6	5.9	Freezing rain, ice starting to break out
April 11			7.1	7.1	Wet snow
April 12	7.0		7.0	7.4	Partly cloudy, windy
April 13		6.27	7.0		
April 14		6.36	6.9		
April 15			7.2	7.3	Sunny, light wind
April 16	7.0		7.2	7.3	Cloudy, light wind
April 17		6.21	7.4	7.5	Sunny
April 18			7.6		Sunny
April 19	7.5		7.5		
April 20		6.44	6.4		
April 21		6.49	6.7		
April 22		5.97	6.8	6.4	Rain, ice is out
April 23	6.0	6.04	6.4	4.9	Water very high
April 24		6.10	6.4	5.1	Water very high
April 25			6.6	5.1	Water very high
April 26	6.7		6.5		
April 27		6.22	6.7		
April 28			6.8		
April 29			6.7	6.4	Water getting lower
April 30	7.0		6.7	6.0	Water getting lower
May 1		6.53	6.7	6.2	Rainy day, water steady
May 2		6.21	7.2	5.9	Water steady, overcast
May 3	7.0		6.3	5.8	Rain
May 4			6.5		
May 5			6.7		
May 6			7.2		
May 7	6.5		6.8	6.0	Overcast (no rain), water getting lower
May 8			6.8	5.8	Cold wind, no rain
May 9			6.7	7.0	Sunny warm day, water getting lower
May 10	7.0		6.8	6.0	Sunny warm day, water getting lower
May 11			6.7		
May 12			6.9		
May 13			6.5		
May 14			6.4	6.9	Sunny warm day, water getting lower

Table VII. Ranges of lowered pH and effects on various fish species.

pH	EFFECT
6.0 - 5.5	Rainbow trout, smallmouth bass, walleye and burbot fail to reproduce.
6.5 - 4.6	Growth of brook trout slowed.
5.8 - 5.2	Lake trout, trout and perch fail to reproduce.
5.5 - 4.5	Brown trout fail to reproduce. Mortality of adult lake trout.
5.2 - 4.7	Northern pike, brown bullhead, white sucker, pumpkinseed fail to reproduce.
5.0	Atlantic salmon fail to reproduce.
5.0 - 4.5	Brook trout fail to reproduce.
4.7 - 4.5	Lake herring, yellow perch, lake chub, rock bass fail to reproduce.
4.5	Mortality of adult Atlantic salmon.
4.5 - 3.5	Mortality of adult brook trout.

(Modified from International Angler, Vol. 43)

Table VIII

MIRAMICHI RIVER ESTUARY POINT SOURCE STUDY

DAY 1

Facility	Flow (m3/d)	BOD Conc (mg/l)	BOD Load (kg/d)	SS Conc (mg/l)	SS Load (kg/d)	FC Conc (MPN/100ml)	FC Load (MPN/d)
Municipal							
Chatham	3100	9	27.90	4.9	15.19	160000	4.96E+12
Douglastown	710	10	7.10	10	7.10	17000	1.21E+11
Loggieville	103	20	2.06	35	3.61	35000	3.61E+10
Nelson-Miramichi	963		10.03		9.69		
North Lagoon	195	16	3.12	30	5.85		
South Lagoon	768	9	6.91	5	3.84		
Newcastle	7074		164.97		169.71		2.78E+13
Untreated	2814	45	126.63	60	168.84	950000	2.67E+13
Treated	4260	9	38.34	4.9	20.87	24000	1.02E+12
Industrial							
MP&P Nelson	11764	340	3999.76	100	1176.40	2400	2.82E+11
MP&P Newcastle							
Domestic	295	9	2.66	4.9	1.45		
Industrial	82251	70	5757.57	120	9870.12	54000	4.44E+13
Northwood P&T	98.1	9	0.88	6	0.59	170000	1.67E+11
Other							
Atlantic Institute	0	27	0.00	34	0.00		
Burnt Church IR	160	12	1.92	32	5.12	920	1.47E+09
CFB Chatham	1318	13	17.13	5	6.59		
CFB St Margarets	70	9	0.63	4.9	0.34		
Eel Ground IR	0	12	0.00	23	0.00	12000	0.00E+00

Note: Concentration <10 = 9
Concentration <5 = 4.9

DAY 1 refers to first day or 24hr period of sampling at the site; this may not necessarily be the same date for all sites - refer to the individual survey results.

Table VIII continued

MIRAMICHI RIVER ESTUARY POINT SOURCE STUDY

DAY 2

Facility	Flow (m3/d)	BOD Conc (mg/l)	BOD Load (kg/d)	SS Conc (mg/l)	SS Load (kg/d)	FC Conc (MPN/100ml	FC Load (MPN/d)
Municipal							
Chatham	3100	9	27.90	4.9	15.19	160000	4.96E+12
Douglastown	623	9	5.61	9	5.61	5400	3.36E+10
Loggieville	103	40	4.12	40	4.12	9200	9.48E+09
Nelson-Miramichi			11.01		15.48		4.10E+11
North Lagoon	195	21	4.10	40	7.80	210000	4.10E+11
South Lagoon	768	9	6.91	10	7.68	79	6.07E+08
Newcastle			263.46		217.85		1.91E+13
Untreated	2814	80	225.12	70	196.98	540000	1.52E+13
Treated	4260	9	38.34	4.9	20.87	92000	3.92E+12
Industrial							
MP&P Nelson	8425	290	2443.25	90	758.25	5400	4.55E+11
MP&P Newcastle							
Domestic							
Industrial	76255	80	6100.40	60	4575.30	240000	1.83E+14
Northwood P&T	89.2	9	0.80	20	1.78	70000	6.24E+10
Other							
Atlantic Institute							
Burnt Church IR	160	10	1.60	35	5.60	49	7.84E+07
CFB Chatham	1255	9	11.30	7	8.79		
CFB St Margarets	70	9	0.63	10	0.70		
Eel Ground IR							

Note: Concentration <10 = 9
Concentration <5 = 4.9

DAY 2 refers to second day or 24hr period of sampling at the site; this may not necessarily be the same date for all sites - refer to the individual survey results.

Table VIII continued

MIRAMICHI RIVER ESTUARY POINT SOURCE STUDY

DAY 3

Facility	Flow (m3/d)	BOD Conc (mg/l)	BOD Load (kg/d)	SS Conc (mg/l)	SS Load (kg/d)	FC Conc (MPN/100ml)	FC Load (MPN/d)
Municipal							
Chatham	3100	9	27.90	4.9	15.19	24000	7.44E+11
Douglastown	631	10	6.31	21	13.25	3500	2.21E+10
Loggieville	103	35	3.61	45	4.64		
Nelson-Miramichi			10.23		13.52		
North Lagoon	195	17	3.32	26	5.07		
South Lagoon	768	9	6.91	11	8.45		
Newcastle			179.04		147.50		6.98E+13
Untreated	2814	50	140.70	45	126.63	2400000	6.75E+13
Treated	4260	9	38.34	4.9	20.87	54000	2.30E+12
Industrial							
MP&P Nelson	11764	290	3411.56	100	1176.40	9200	1.08E+12
MP&P Newcastle							
Domestic							
Industrial	81161	40	3246.44	140	11362.54	23	1.87E+10
Northwood P&T	99.2	9	0.89	4.9	0.49	70000	6.94E+10
Other							
Atlantic Institute							
Burnt Church IR	160	11	1.76	25	4.00	170	2.72E+08
CFB Chatham	1282	9	11.54	6	7.69	1.9	2.44E+07
CFB St Margarets	56.5	9	0.51	13	0.73	79	4.46E+07
Eel Ground IR							

Note: Concentration <10 = 9
Concentration <5 = 4.5

DAY 3 refers to third day or 24hr period of sampling at the site; this may not necessarily be the same date for all sites - refer to the individual survey results.

Table IX. Large Sewage Treatment Plants

SITE INCLUDED IN THIS REPORT	BOD_5 Mg/L	SS Mg/L	TP	TKN
Provincial Discharge Standard Limit	20	20	3	8
Rogersville Lagoon #1 (May 30'91)	48	103	4.9	24
" " " (Aug.14'91)	5	47	3.3	5
Rogersville Lagoon #2 (May 30'91)	3	15	3	12
Blackville (May 27'91)	44	13	2	10
" (Aug.12'91)	26	12	3	12
Doaktown (Jul 26'90)	14	22	2	3

Table X. Small sewage treatment plants.

SITE INCLUDED IN THIS REPORT	BOD_5 mg/L	SS mg/L	FC -	Overall rating
Provincial discharge standard limits	20	20		
1) Blackville Elementary School*1	-	-	-	N.A.
2) North and South Esk High School	14	31	-*2	Fair
3) Baie Ste. Anne School	4	6	-	Good
4) Upper Miramichi High School	-	-	-	Good*3
5) Millerton Junior High School	21	20	-	Good
6) David Curtis Mobile Home Park	-	-	-	Good*3
7) Maritime Mobile Home Park	-	-	-	Good*3
8) Kerr Mobile Home Park	57	43	9,000	Fair
9) MacTavish Mobile Home Park*4	105	35	TNTC	Poor
10) C.A. Clark Mobile Home Park	71	57	TNTC	Poor
11) Millerton Estates Subdivision	73	29	TNTC	Poor
12) The Enclosure Park	-	-	-	Good*3
13) KOA Campground	81	139	TNTC	Poor
14) Central NB Nursing Home	41	47	<10	Fair

*1
*2Discharges directly into Blackville Municipal Treatment Plant.
No limit imposed unless discharge affects wimming area or shellfish
*3harvesting area.
*4Rating based on visual and olfactory inspection only.
Sewage treatment plant was being by-passed.

Table XI. Last spring day with ice effect at Gauge.

Year	Northwest Miramichi River at Trout Brook 01BQ001	Southwest Miramichi River at Blackville 01B0001	Renous River at McGraw Brook 01B0002
1969	April 17	April 25	May 5
1970	April 30	April 10 (mid-winter Feb. 5)	April 19
1971	April 20	April 13	April 22
1972	April 28	April 29	April 30
1973	April 18	April 1	April 18
1974	April 30	April 20	May 2
1975	April 30	April 21	April 27
1976	April 10	April 9	April 15
1977	April 22	April 19	April 23
1978	May 1	April 30	April 30
1979	March 27	March 26	Arpil 1
1980	April 18	April 9	April 16
1981	April 8	March 24	April 7
1982	April 23	April 27	April 22
1983	April 12	March 23	April 15
1984	April 19	April 20	April 22
1985	April 14	April 8	April 14
1986	April 16	April 25	April 18
1987	April 4	April 4	April 2
1988	April 2	March 29	April 6
1989	-	April 7	April 3

Table XII. Date of highest spring flow.
(Based on recorded maximum daily discharges)

Year	Northwest Miramichi River at Trout Brook 01BQ001	Southwest Miramichi River at Blackville 01B0001	Renous River at McGraw Brook 01B0002
1966	May 18	April 23	May 21
1967	May 21	May 13	May 20
1968	May 13	April 15	April 26
1969	May 21	May 11	May 21
1970	May 3 (higher on Feb. 4)	May 19	May 7
1971	May 5	May 5	May 5
1972	May 19	May 17	May 16
1973	April 30	April 30	April 29
1974	May 2	May 2	April 30
1975	May 13	May 8	May 13
1976	April 3	April 3	May 13
1977	April 23	May 1	April 23
1978	May 11	May 11	May 10
1979	April 30	March 27	April 30
1980	April 24	April 24	April 24
1981	April 6	April 11	April 6
1982	April 28	April 28	April 28
1983	April 18	April 19	April 18
1984	May 2	May 2	May 2
1985	May 19	May 20	May 19
1986	April 24	April 25	April 26
1987	April 5	April 4	April 2
1988	April 11	April 1	March 29
1989	-	April 8	April 7

TABLE XIII

March 8,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

HEAVY METAL RESULTS REPORTED IN mg/kg OR PPM DRY WEIGHT BASIS

Detection Level is metal specific – "<" sign indicates detection level

Note #1 – Mercury Results were variable. Standard Deviation in brackets after result.

Limit is corrected to dry weight basis by multipying wet weight limits by 4 which assumes 75% moisture in biota

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion) NS = Insufficient Sample

MOISTURE CONTENT: Values in brackets are normal moisture content of the species.

SPECIES	LIMIT	MUSSEL	OYSTER	LOBSTER	LOBSTER	LOBSTER	LOBSTER	MUSSEL
PORTION	TABLE XX	EDIBLE	EDIBLE	FLESH	HEPATOPAN	FLESH	HEPATOPAN	EDIBLE
LOCATION	REF # 1	B1	B1	B2	B2	B3	B3	B4
DATE		9/7/90	9/7/90	16/5/90	16/5/90	16/5/90	16/5/90	9/7/90
SIZE		6.4 cm	8.9 cm	20 cm	20 cm	23 cm	23 cm	7.8 cm
LAB #				JH1	JH1			
% LIPID		0.24	1.2					0.74
% MOISTURE		11.5 (84)	14.9 (82)					15.2 (84)
CADMIUM		2.6	4.6	0.2	3.5	0.9	5.7	2.4
LEAD		8.2	<5.0	<5.0	<5.0	<5.0	<5.0	9.5
COPPER		7.5	71	75	28.3	63	28.5	9.2
ZINC		62.3	4463	156	47.3	160	70	79
MERCURY	2.0	0.28	0.67 (0.43)	0.21	0.25	0.41 (0.23)	0.2	0.15 (0.08)

TABLE XIII

March 8,1992

SPECIES	LIMIT	OYSTER	CLAM	LOBSTER	LOBSTER	OYSTER	MUSSEL	CLAM
PORTION	TABLE XX	EDIBLE	EDIBLE	FLESH	HEPATOPAN	EDIBLE	EDIBLE	EDIBLE
LOCATION	REF # 1	B5	B6	B7	B7	B8	B8	B8
DATE		9/7/90	9/7/90	20/5/90	20/5/90	9/7/90	9/7/90	9/7/90
SIZE		8.5 cm		25 cm	25 cm	7.9 cm	5.9 cm	
LAB #								
% LIPID		0.80				0.30	0.80	
% MOISTURE		17.3 (82)				30.3 (82)	15.3 (84)	
CADMIUM		5	0.8	0.4	5.4	5.1	2.7	0.8
LEAD		7.3	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
COPPER		169	10.8	58	26.3	243	5.1	9.9
ZINC		6896	136.9	166	50	9742	57.4	117
MERCURY	2.0	0.55	0.16	0.26	0.29	0.62	0.4	0.33

TABLE XIII

March 8,1992

SPECIES	LIMIT	MUSSEL	CLAM	OYSTER	TOMCOD	CLAM	SHAD	GASPEREAU
PORTION	TABLE XX	EDIBLE	EDIBLE	EDIBLE	LIVER	EDIBLE	FLESH	FLESH
LOCATION	REF # 1	B11	B12	B12	B14	B15	B16	B16
DATE		9/7/90	9/7/90	9/7/90	6/2/91	9/7/90	16/10/90	16/10/90
SIZE		4.2 cm		6.6 cm	28 cm			
LAB #								
% LIPID		1.3		0.44	16.9			
% MOISTURE		23.7 (84)		11.1 (82)	30.9 (75)			
CADMIUM		1.3	0.8	4.6	<0.10	0.8	<0.10	<0.10
LEAD		6.7	5.1	9	<5.0	7	<5.0	<5.0
COPPER		6	11.3	239	2.9	14.1	2.1	3.2
ZINC		86.9	129	11417	47.2	173	11.3	23.1
MERCURY	2.0	0.19	0.2	0.48	0.40	0.25	0.15	0.19

TABLE XIII

March 8,1992

SPECIES	LIMIT	AM.EEL	W.SUCKER	FLOUNDER	SHAD	GASPEREAU	STRIPED BASS	W.SUCKER
PORTION	TABLE XX	FLESH	FLESH	FLESH	FLESH	FLESH	FLESH	FLESH
LOCATION	REF # 1	B16	B16	B23	B23	B23	B23	B24
DATE		16/10/90	16/10/90	7/6/90	1/6/90	1/6/90	1/6/90	1/6/90
SIZE		67 cm		15 cm	50 cm	25 cm	35 cm	25 cm
LAB #								
% LIPID		7.7				5.5	4.5	1.9
% MOISTURE		32.9 (75)				29.6 (75)	29.6 (75)	24.4 (75)
CADMIUM		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
LEAD		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
COPPER		0.8	1.1	2.8	3.4	3.6	1.6	2.2
ZINC		68.9	24	38.4	13	14.6	16.4	30.9
MERCURY	2.0	0.32	0.29	0.24	0.18	0.39	2.8	2.51

Note: Limit of 2.0 mg/kg is for unrestricted consumption by children under 15 years and women of childbearing age. Limit of 4.0 mg/kg applies to others eating no more than one half pound every week for life.

TABLE XIII

March 8,1992

SPECIES	LIMIT	AM.EEL	AM.EEL
PORTION	TABLE XX	FLESH	LIVER
LOCATION	REF # 1	B27	328
DATE		1/6/90	18/12/90
SIZE		53 cm	
LAB #			
% LIPID			
% MOISTURE			
CADMIUM		<0.10	0.31
LEAD		<5.0	<5.0
COPPER		0.6	36.8
ZINC		71.3	156.2
MERCURY	2.0	0.36	NS

TABLE XIV

March 9,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

CHLORINATEDDIOXIN/FURANRESULTS IN pg/g OR PPT WET WEIGHT

Detection Level is isomer specific – "<" sign indicates detection level

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

MOISTURE CONTENT: Values in brackets are normal moisture content of the species. Where test results are also in brackets, they have been corrected to the normal moisture content.

SPECIES	LIMIT	TOMCOD	STRIPED BASS	SALMON	SALMON	SALMON+GRILSE	SALMON+GRILSE
PORTION	TABLE XX	LIVER	WHOLE	LIVER	FLESH	FLESH	LIVER
LOCATION	REF # 2	B14	B16	B16	B16	B17	B17
DATE		6/2/91	16/10/90			21/9/90	21/9/90
SIZE	see note	28 cm	26 cm	70.6 g		Both 70 cm	Both 70 cm
ENVIROTEST LAB #	in Ref #2	D1159–10	D1159–12	D1003–3	D1003–1	D1159–26	D1159–27
RESULTS							
% LIPID		16.9	5.4				
% MOISTURE		30.9 (75)	30.6 (75)				
2378–TCDD	20.0	3.20 (1.16)	8.50 (3.06)	<0.44	0.51	1.84	1.00
12378 P5CDD		<0.21	<0.40	<0.55	<1.39	<0.29	<0.30
123478 H6CDD		<0.41	<0.52	<0.59	<1.72	<0.55	<0.67
123678 H6CDD		1.20	<0.63	<0.68	<1.99	<0.61	<0.82
123789 H6CDD		<0.45	<0.59	<0.61	<1.77	<0.60	<0.76
1234678 H7CDD		<0.72	<0.78	1.36	<2.85	<0.66	<0.79
OCDD		<1.80	<1.40	7.28	<4.74	<1.40	4.10
2378–TCDF		14.00 (5.07)	34.00 (12.24)	1.19	2.43	8.50	3.50
12378 P5CDF		0.52	<0.37	<0.47	<0.95	<0.27	<0.37
23478 P5CDF		<0.21	0.74	<0.95	<1.93	<0.24	<0.36
123478 H6CDF		<0.34	<0.41	<0.43	<0.84	<0.22	<0.41
123678 H6CDF		<0.26	<0.34	<0.51	<1.00	<0.18	<0.34
234678 H6CDF		<0.32	<0.38	<0.63	<1.24	<0.21	<0.39
123789 H6CDF		<0.45	<0.58	<0.84	<1.66	<0.27	<0.60
1234678 H7CDF		<0.37	<0.42	<0.84	<1.28	<0.33	<0.58
1234789 H7CDF		<0.86	<0.85	<1.03	<1.68	<0.89	<1.30
OCDF		<1.40	<1.20	<1.65	<4.52	<1.10	<2.30

TABLE XIV

March 9,1992

SPECIES	LIMIT	AM.EEL	STRIPED BASS	W.SUCKER
PORTION	TABLE XX	WHOLE	WHOLE	WHOLE
LOCATION	REF # 2	B20	B23	B24
DATE		FALL 1988	1/6/90	1/6/90
SIZE	see note	67 cm	35 cm	25 cm
ENVIROTEST LAB #	in Ref #2	D1003-2	D1159-11	D1159-16
RESULTS				
% LIPID			4.5	1.9
% MOISTURE			29.6 (75)	24.4 (75)
2378-TCDD	20.0	6.90	16.00 (5.68)	5.40 (1.79)
12378 P5CDD		3.93	1.60	0.42
123478 H6CDD		2.86	<0.44	<0.43
123678 H6CDD		25.52	<0.56	<0.49
123789 H6CDD		2.67	<0.51	<0.47
1234678 H7CDD		16.52	0.77	<0.70
OCDD		17.84	<1.40	1.90
2378-TCDF		1.05	56.00 (19.88)	30.00 (9.92)
12378 P5CDF		0.92	<0.27	<0.20
23478 P5CDF		0.84	1.30	0.25
123478 H6CDF		0.80	<0.40	<0.22
123678 H6CDF		0.65	<0.33	<0.18
234678 H6CDF		0.83	<0.38	<0.21
123789 H6CDF		<0.90	<0.55	<0.27
1234678 H7CDF		3.86	<0.32	<0.40
1234789 H7CDF		<0.88	<0.68	<1.10
OCDF		<2.51	<1.20	<1.00

TABLE XIV A

March 9,1992

DEPT OF FISHERIES AND OCEANS DATA

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY DEPT OF FISHERIES AND OCEANS

CHLORINATEDDIOXIN/FURANRESULTS IN pg/g OR PPT WET WEIGHT

Detection Level is isomer specific – "<" sign indicates detection level

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

SPECIES	LIMIT	OYSTER	CLAM	QUAHAUG	LOBSTER	LOBSTER	LOBSTER
PORTION	TABLE XX	SOFT TISSUE	SOFT TISSUE	SOFT TISSUE	MUSCLE	MUSCLE	HEPATOPAN
LOCATION	REF #2	B1	B1	B1	B7	B-10	B-10a
DATE		1989	1989	1989	1989	1989	1989
SIZE	see note						
RESULTS	in Ref #2						
% LIPID							
% MOISTURE							
2378-TCDD	20.0	<0.9	<0.6	<0.6	<1.0	<0.5	16.0
12378 P5CDD		<2.0	<1.7	<1.5	NR	<1.9	NR
123478 H6CDD		<2.7	<1.8	<1.7	NR	<3.2	NR
123678 H6CDD		NR	NR	NR	NR	NR	NR
123789 H6CDD		NR	NR	NR	NR	NR	NR
1234678 H7CDD		<4.7	<4.7	<4.3	<2.0	<3.2	NR
OCDD		<15.0	<18.0	<8.4	<10.0	<8.0	<26.0
2378-TCDF		3.6	1.7	0.9	1.5	2.8	174.0
12378 P5CDF		<1.0	<1.0	<0.8	NR	<0.8	NR
23478 P5CDF		NR	NR	NR	NR	NR	NR
123478 H6CDF		<2.9	<2.6	<2.3	NR	<2.4	NR
123678 H6CDF		NR	NR	NR	NR	NR	NR
234678 H6CDF		NR	NR	NR	NR	NR	NR
123789 H6CDF		NR	NR	NR	NR	NR	NR
1234678 H7CDF		<4.0	<4.4	<4.0	NR	<2.6	NR
1234789 H7CDF		NR	NR	NR	NR	NR	NR
OCDF		<20.0	<9.8	<12.0	<1.0	<7.7	<22.0

TABLE XIV A

March 9,1992

SPECIES	LIMIT	LOBSTER	OYSTER	MUSSEL	CLAM	LOBSTER	ROCK CRAB	GRILSE
PORTION	TABLE XX	HEPATOPAN	SOFT TISSUE	SOFT TISSUE	SOFT TISSUE	MUSCLE	MUSCLE	WHOLE FISH
LOCATION	REF #2	B-10b	B12	B12	B12	B16	B16	B16
DATE		1990	1989	1989	1989	1989	1989	1989
SIZE	see note							
RESULTS	in Ref #2							
% LIPID		18.2						
% MOISTURE		67.9						
2378-TCDD	20.0	22.3	<1.3	0.76	<0.7	<1.0	<0.5	<0.8
12378 P5CDD		<2.0	<2.7	NR	<1.5	NR	NR	<1.3
123478 H6CDD		<3.0	NR	NR	<2.0	NR	NR	<2.0
123678 H6CDD		NR	NR	NR	NR	NR	NR	NR
123789 H6CDD		NR	<4.2	NR	NR	NR	NR	NR
1234678 H7CDD		<7.0	<7.2	<1.0	<4.2	NR	<2.0	<4.0
OCDD		<7.0	<15.0	<10.0	<15.0	<2.0	<10.0	<10.0
2378-TCDF		173.5	9.0	7.0	3.0	<1.0	3.9	2.3
12378 P5CDF		<1.0	<1.8	NR	<0.8	NR	NR	<0.9
23478 P5CDF		NR	NR	NR	NR	NR	NR	NR
123478 H6CDF		<2.0	<4.5	NR	<2.1	NR	NR	<2.4
123678 H6CDF		NR	NR	NR	NR	NR	NR	NR
234678 H6CDF		NR	NR	NR	NR	NR	NR	NR
123789 H6CDF		NR	NR	NR	NR	NR	NR	NR
1234678 H7CDF		<3.0	<6.1	NR	<3.3	NR	NR	<3.3
1234789 H7CDF		NR	NR	NR	NR	NR	1.3	NR
OCDF		<7.0	<16.0	<1.0	<7.4	<1.0	<1.0	<20.0

TABLE XIV A

March 9,1992

SPECIES	LIMIT	GRILSE	STRIPED BASS	WHITE SUCKER	WHITE SUCKER	STRIPED BASS	FLOUNDER	WHITE SUCKER
PORTION	TABLE XX	FILLET	FILLET	WHOLE FISH	FILLET	FILLET	FILLET	WHOLE FISH
LOCATION	REF #2	B16	B16	B20	B20	B20	B23	B23
DATE		1989	1989	1989	1989	1989	1989	1989
SIZE	see note							
RESULTS	in Ref #2							
% LIPID								
% MOISTURE								
2378-TCDD	20.0	<0.6	1.2	9.5	1.9	2.9	1.6	8.6
12378 P5CDD		<1.5	NR	NR	NR	NR	NR	NR
123478 H6CDD		<2.0	NR	NR	NR	NR	NR	NR
123678 H6CDD		NR	NR	NR	NR	NR	NR	NR
123789 H6CDD		NR	NR	NR	NR	NR	NR	NR
1234678 H7CDD		<3.1	<1.0	1.9	NR	NR	NR	NR
OCDD		<6.7	<10.0	<2.0	<2.0	<2.0	<2.0	15.0
2378-TCDF		1.0	4.4	68.0	11.0	11.0	3.4	56.0
12378 P5CDF		<0.7	NR	NR	NR	NR	NR	NR
23478 P5CDF		NR	NR	NR	NR	NR	NR	NR
123478 H6CDF		<2.5	NR	NR	NR	NR	NR	NR
123678 H6CDF		NR	NR	NR	NR	NR	NR	NR
234678 H6CDF		NR	NR	NR	NR	NR	NR	NR
123789 H6CDF		NR	NR	NR	NR	NR	NR	NR
1234678 H7CDF		<2.5	NR	NR	NR	NR	NR	NR
1234789 H7CDF		NR	NR	NR	NR	NR	NR	NR
OCDF		<2.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

TABLE XIV A

March 9,1992

SPECIES	LIMIT	WHITE SUCKER	STRIPED BASS	AMER. EEL
PORTION	TABLE XX	FILLET	FILLET	FILLET
LOCATION	REF #2	B23	B23	B23
DATE		1989	1989	1989
SIZE	see note			
RESULTS	in Ref #2			
% LIPID				
% MOISTURE				
2378-TCDD	20.0	1.8	3.0	6.4
12378 P5CDD		NR	NR	NR
123478 H6CDD		NR	NR	NR
123678 H6CDD		NR	NR	NR
123789 H6CDD		NR	NR	NR
1234678 H7CDD		NR	NR	1.4
OCDD		12.0	7.8	11.0
2378-TCDF		11.0	13.0	2.3
12378 P5CDF		NR	NR	NR
23478 P5CDF		NR	NR	NR
123478 H6CDF		NR	NR	NR
123678 H6CDF		NR	NR	NR
234678 H6CDF		NR	NR	NR
123789 H6CDF		NR	NR	NR
1234678 H7CDF		NR	NR	NR
1234789 H7CDF		NR	NR	NR
OCDF		<1.0	<1.0	<1.0

TABLE XV

March 9,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

CHLORINATED PESTICIDE RESULTS IN ng/g OR PPB WET WEIGHT

ND means below Detection Level = 1.0 PPB

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

MOISTURE CONTENT: Values in brackets are normal moisture content of the species. Where test results are also in brackets, they have been corrected to the normal moisture content.

SPECIES	LIMIT	LOBSTER	LOBSTER	LOBSTER	LOBSTER	TOMCOD	STRIPED	AM.EEL	STRIPED BASS	GASPEREAU	W.SUCKER
PORTION	TABLE XX	HEPATOPAN	HEPATOPAN	HEPATOPAN	HEPATOPAN	LIVER	BASS	WHOLE	WHOLE	WHOLE	WHOLE
LOCATION	REF #1	B2	B3	B7	B10b	B14	B16	B16	B23	B23	B24
DATE		16/5/90	16/5/90	16/5/90	15/8/91	6/2/91	16/10/90	16/10/90	1/6/90	1/6/90	1/6/90
SIZE		20 cm	23 cm	25 cm	22 cm	28 cm	26 cm	67 cm	35 cm	25 cm	25 cm
ENVIROTEST LAB #		D1159-13	D1159-13	JH3	DFO 757-H	D1159-10	D1159-12	D1159-15	D1159-11	D1159-14	D1159-16
RESULTS											
% LIPID				25.8	18.2			7.7	4.5	5.5	1.9
% MOISTURE					67.9			32.9 (75)	29.6 (75)	29.6 (75)	24.4 (75)
HCB		*	1.3					ND		1.0	ND
alpha - BHC			9.0					1.2		1.1	ND
gamma-BHC			2.2					ND		ND	ND
beta-BHC			2.5					ND		ND	ND
Ronnel			1.9					1.5		ND	ND
Heptachlor Eposide			2.7					ND		ND	ND
DDE			99	**20	**20	120	70	85	86	43	46
Dieldrin			5.3					2.1		3.3	ND
DDD			ND			ND	ND	ND	ND	ND	ND
DDT	*** 5000		ND			ND	ND	ND	ND	ND	ND
Methoxychlor			1.7					ND		ND	ND
Heptachlor			ND					ND		ND	ND
Aldrin			ND					ND		ND	ND
Oxychlor			ND					ND		ND	ND
gamma-Clordane			ND					ND		ND	ND
Mirex	100		ND					ND		ND	ND
alpha-Chlordane			ND					ND		ND	ND

* Lobster Hepatopancreas for Locations B2 and B3 was combined for analysis

** Analysis by DFO, St. Andrews

*** From 1986 Guide to Eating Ontario Sport Fish

TABLE XVI

March 9,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

CHLOROPHENOL RESULTS IN ng/g OR PPB WET WEIGHT BASIS

ND means below Detection Level = 1.0 PPB

Note #2 – JH1 and JH2 hepatopanxreas were combined for PAH and chlorinated phenol determination.

Note #3 – JH16+JH17+JH18 were combined for chlorophenols due to sample size.

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

MOISTURE CONTENT: Values in brackets are normal moisture content of the species. Where test results are also in brackets, they have been corrected to the normal moisture content.

SPECIES	LIMIT	OYSTER	MUSSEL	LOBSTER	LOBSTER	MUSSEL	OYSTER	OYSTER	MUSSEL	MUSSEL	OYSTER
PORTION		EDIBLE	EDIBLE	HEPATOPAN	HEPATOPAN	EDIBLE	EDIBLE	EDIBLE	EDIBLE	EDIBLE	EDIBLE
LOCATION		B1	B1	B2	B3	B4	B5	B8	B8	B11	B12
DATE		9/7/90	9/7/90	16/5/90	[illegible]/90	9/7/90	9/7/90	9/7/90	9/7/90	9/7/90	9/7/90
SIZE	No Limits	9 cm	6.4 cm	20 cm	2[illegible] cm	7.7 cm	8.5 cm	7.9 cm	5.9 cm	4.2 cm	6.6 cm
ENVIROTEST LAB #	Available	D1159–21	D1159–25	D1159–13	D1159–13	D1159–24	D1159–20	D1159–19	D1159–23	D1159–22	D1159–18
RESULTS											
% LIPID		1.2	0.24			0.74	0.80	0.30	0.80	1.3	0.44
% MOISTURE		14.9 (82)	11.5 (84)			15.2 (84)	17.3 (82)	30.3 (82)	15.3 (84)	23.7 (84)	11.1 (82)
CHLOROPHENOLS					Note #2						
2,4–di		ND	ND		ND	6	ND	ND	10	4	6
2,4,6–tri		ND	ND		53	3	1	ND	7	25	ND
2,3,4,6–tetra		ND	ND		ND	3	ND	ND	6	ND	1
penta		1	1		ND	1	ND	1	2	1	ND
CHLOROCATECHOLS											
3,4–di		ND	ND		11	ND	ND	ND	3	ND	ND
3,5–di		ND	ND		ND	ND	ND	ND	ND	ND	ND
4,5–di		ND	ND		19	ND	ND	ND	ND	ND	ND
3,4,5–tri		ND	ND		ND	ND	ND	ND	ND	1	ND
3,4,6–tri		ND	ND		ND	160	ND	ND	157	ND	ND
tetra		ND	ND		ND	1	ND	ND	ND	ND	ND
CHLOROGUAIACOLS											
3,4–di		ND	ND		ND	ND	ND	ND	ND	ND	ND
4,5–di		ND	ND		ND	ND	ND	ND	ND	ND	2
4,6–di		ND	ND		ND	ND	ND	ND	ND	ND	ND
3,4,5–tri		ND	ND		ND	ND	ND	ND	2	ND	ND
3,4,6–tri		ND	ND		5	ND	ND	ND	ND	ND	1
4,5,6–tri		ND	ND		ND	ND	ND	ND	ND	ND	ND
tetra		ND	ND		ND	1	ND	ND	3	1	ND
CHLOROVERATROLES											
4,5–di		ND	ND		ND	ND	ND	ND	ND	ND	ND
3,4,5–tri		2.5	3		ND	6	1	16	21	15	1
tetra		ND	ND		17	ND	ND	ND	ND	ND	ND
6–chlorovanillin		ND	ND		ND	ND	ND	ND	ND	ND	ND
5,6–dichlorovanil		ND	ND		ND	ND	ND	ND	ND	1	ND
4,5,6–trichloro–syringol		2.0	ND		ND	ND	6	1	8	12	ND
4,5,6–trichloro–trimethoxybenzene		ND	ND		ND	ND	ND	30	4	ND	ND

TABLE XVI

March 9,1992

SPECIES	LIMIT	TOMCOD	AM.EEL	STRIPED BASS	ALGAE	ALGAE	ALGAE	GASPEREAU	STRIPED BASS	W.SUCKER
PORTION		LIVER	WHOLE	WHOLE				WHOLE	WHOLE	WHOLE
LOCATION		B14	B16	B16	B19	B19	B19	B23	B23	B24
DATE		6/2/91	16/10/90	16/10/90	22/6/90	22/6/90	22/6/90	1/6/90	1/6/90	1/6/90
SIZE	No Limits	28 cm	67 cm	26 cm				25 cm	35 cm	25 cm
ENVIROTEST LAB #	Available	D1159-10	D1159-15	D1159-12	D1159-17			D1159-14	D1159-11	D1159-16
RESULTS										
% LIPID		16.9	7.7	5.4				5.5	4.5	1.9
% MOISTURE		30.9 (75)	32.9 (75)	30.6 (75)				29.6 (75)	29.6 (75)	24.4 (75)
CHLOROPHENOLS					Note #3	*	*		*	
2,4-di		ND	6	ND	4			ND	ND	5
2,4,6-tri		ND	5	ND	9			ND	ND	ND
2,3,4,6-tetra		ND	3	1	ND			2	ND	ND
penta		3	3	ND	2			3	2	5
CHLOROCATECHOLS										
3,4-di		ND	1	ND	ND			2	ND	ND
3,5-di		ND	ND	ND	ND			ND	ND	ND
4,5-di		ND	ND	ND	ND			ND	ND	ND
3,4,5-tri		ND	ND	ND	ND			ND	ND	ND
3,4,6-tri		ND	ND	ND	71			ND	ND	19
tetra		ND	ND	ND	1			ND	ND	ND
CHLOROGUAIACOLS										
3,4-di		ND	ND	ND	ND			ND	3	ND
4,5-di		ND	ND	ND	ND			ND	ND	ND
4,6-di		ND	ND	ND	ND			ND	4	ND
3,4,5-tri		3	5	ND	6			ND	2	2
3,4,6-tri		ND	1	ND	ND			ND	ND	ND
4,5,6-tri		ND	1	ND	ND			ND	ND	ND
tetra		11	8	ND	10			5	8	10
CHLOROVERATROLES										
4,5-di		ND	ND	ND	ND			ND	ND	ND
3,4,5-tri		4	3	7	6			5	ND	4
tetra		ND	ND	ND	ND			ND	ND	ND
6-chlorovanillin		ND	ND	ND	ND			ND	ND	ND
5,6-dichlorovanil		ND	ND	ND	ND			ND	ND	ND
4,5,6-trichloro-syringol		ND	ND	ND	ND			ND	ND	ND
4,5,6-trichloro-trimethoxybenzene		ND	1	ND	ND			ND	ND	ND

TABLE XVII

March 9,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

PAH RESULTS REPORTED IN ng/g OR PPB WET WEIGHT BASIS

NB means below Detection Level noted.

Note #2 – B2 and B3 Lobster hepatopancreas were combined for PAH and chlorinated phenol determination.

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

MOISTURE CONTENT: Values in brackets are normal moisture content of the species. Where test results are also in brackets, they have been corrected to the normal moisture content.

SPECIES		LIMITS	MUSSEL	OYSTER	MUSSEL	OYSTER	LOBSTER	LOBSTER
PORTION			EDIBLE	EDIBLE	EDIBLE	EDIBLE	HEPATOPAN	HEPATOPAN
LOCATION			B1	B1	B4	B5	B7	B10b
DATE			9/7/90	9/7/90	9/7/90	9/7/90	16/5/90	15/8/90
SIZE		No Limits	6.4 cm	8.9 cm	7.8 cm	8.5 cm	25 cm	23 cm
ENVIROTEST LAB #		Available	D1159–25	D1159–21	D1159–24	D1159–20	JH3	DFO 757–H
RESULTS								
% LIPID			0.24	1.2	0.74	0.80		18.2(8.47)
% MOISTURE			11.5 (84)	14.9 (82)	15.2 (84)	17.3 (82)		67.9
PAH	DETECTION LEVEL							
Napthalene	1 PPB		ND	ND	ND	18	ND	ND
Methylnapthalenes	1 PPB		ND	ND	ND	ND	ND	ND
Acenapthylene	1 PPB		ND	ND	ND	ND	ND	ND
Acenapthene	1 PPB		ND	ND	ND	ND	ND	ND
Fluorene	1 PPB		ND	ND	ND	ND	ND	ND
Phenanthrene	1 PPB		ND	ND	ND	7	70	** 50
Fluoranthene	1 PPB		ND	ND	ND	ND	ND	ND
Pyrene	1 PPB		ND	ND	ND	ND	10	** 10
Chrysene/Benzo(a)anthracene	1 PPB		ND	ND	ND	ND	10	** 10
Benzo (b)+(k) fluoranthene	2 PPB		ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	2 PPB		ND	ND	ND	ND	ND	ND
Perylene	2 PPB		ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	3 PPB		ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	3 PPB		ND	ND	ND	ND	ND	ND
Indeno–1,2,3(c,d)pyrene	3 PPB		ND	ND	ND	ND	ND	ND

** Analysis by DFO, St. Andrews

TABLE XVII

March 9,1992

SPECIES		LIMITS	OYSTER	MUSSEL	MUSSEL	OYSTER	AM.EEL
PORTION			EDIBLE	EDIBLE	EDIBLE	EDIBLE	WHOLE
LOCATION			B8	B8	B11	B12	B16
DATE			9/7/90	9/7/90	9/7/90	9/7/90	16/10/90
SIZE		No Limits	7.9 cm	5.9 cm	4.2 cm	6.6 cm	67 cm
ENVIROTEST LAB #		Available	D1159-19	D1159-23	D1159-22	D1159-18	D1159-15
RESULTS							
% LIPID			0.30	0.80	1.3	0.44	7.7
% MOISTURE			30.3 (82)	15.3 (84)	23.7 (84)	11.1 (82)	32.9 (75)
	DETECTION						
PAH	LEVEL						
Napthalene	1 PPB		ND	ND	ND	13	12
Methylnapthalenes	1 PPB		ND	ND	ND	28	ND
Acenapthylene	1 PPB		ND	ND	ND	ND	ND
Acenapthene	1 PPB		ND	ND	ND	ND	ND
Fluorene	1 PPB		ND	ND	ND	ND	ND
Phenanthrene	1 PPB		ND	ND	ND	12	ND
Fluoranthene	1 PPB		ND	ND	ND	ND	ND
Pyrene	1 PPB		ND	ND	ND	ND	ND
Chrysene/Benzo(a)anthracene	1 PPB		ND	ND	ND	ND	ND
Benzo (b)+(k) fluoranthene	2 PPB		ND	ND	ND	ND	ND
Benzo(a)pyrene	2 PPB		ND	ND	ND	ND	ND
Perylene	2 PPB		ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	3 PPB		ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	3 PPB		ND	ND	ND	ND	ND
Indeno-1,2,3(c,d)pyrene	3 PPB		ND	ND	ND	ND	ND

** Analysis by DFO, St. Andrews

TABLE XVIII

March 9,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

PCB RESULTS IN ng/g OR PPB WET WEIGHT BASIS

ND means below Detection Level = 1.0 PPB

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

MOISTURE CONTENT: Values in brackets are normal moisture content of the species. Where test results are also in brackets, they have been corrected to the normal moisture content.

SPECIES	LIMIT	LOBSTER	LOBSTER	LOBSTER	LOBSTER	TOMCOD	STRIPED BASS	AMERICAN	GASPEREAU	STRIPED BASS	W.SUCKER
PORTION	TABLE XX	HEPATOPAN	HEPATOPAN	HEPATOPAN	HEPATOPAN	LIVER	WHOLE	EEL	WHOLE	WHOLE	WHOLE
LOCATION	REF #1	B2	B3	B7	B10b	B14	B16	B16	B23	B23	B24
DATE		16/5/90	16/5/90	16/5/90	15/8/90	6/2/91	16/10/90	16/10/90	1/6/90	1/6/90	1/6/90
SIZE		20 cm	23 cm	23 cm	23 cm	28 cm	26 cm	67 cm	25 cm	35 cm	25 cm
ENVIROTEST LAB #		D1159-13	D1159-13	JH3	DFO 757-H	D1159-10	D1159-12	D1159-15	D1159-14	D1159-11	D1159-16
RESULTS											
% LIPID				25.8	18.2(8.47)	16.9	5.4	7.7	5.5	4.5	1.9
% MOISTURE					67.9	30.9 (75)	30.6 (75)	32.9 (75)	29.6 (75)	29.6 (75)	24.4 (75)
TOTAL PCB's	2,000										
PCB 28			5.9			4.1	3.4	ND	6.7	1.4	1.4
PCB 52			4.0			4.9	6.6	6.7	6.5	3.2	ND
PCB 66			6.4			8.5	5.7	4.3	8.5	5.4	2.6
PCB 101			4.7			11	5.5	8.6	10.7	9.3	3.3
PCB 118			36			31	14	3.8	7.9	6.9	ND
PCB 105/153			17	** 20	** 10	18	6.4	11	9.2	9.8	3.9
PCB 137			3.2			2.6	1.5	1.2	1.2	1.9	ND
PCB 138			18	** 20	** 10	15	6.0	10	4.8	8.6	ND
PCB 183			10.0			10.0	3.8	ND	2.8	6.2	ND
PCB 180			8.8			11	3.6	ND	2.6	11.5	ND

** Analysis by DFO, St. Andrews

TABLE XIX

March 9,1992

MIRAMICHI RIVER ENVIRONMENTAL ASSESSMENT COMMITTEE

BIOTA TEST RESULTS – SAMPLES COLLECTED/ANALYSED BY MREAC

EXTRACTABLE ORGANOCHLORINE RESULTS IN ug/g OR PPM WET WEIGHT BASIS

ND means below Detection Level = 0.50 ug/g (PPM)

PPM = mg/kg = ug/g (Parts per Million); PPB = ug/kg = ng/g (Parts per Billion); PPT = ng/kg = pg/g (Parts per Trillion)

MOISTURE CONTENT: Values in brackets are normal moisture content of the species. Where test results are also in brackets, they have been corrected to the normal moisture content.

SPECIES	LIMITS	MUSSEL	OYSTER	MUSSEL	OYSTER	MUSSEL	MUSSEL (REPEAT)	MUSSEL (CONTROL)
PORTION		EDIBLE	EDIBLE	EDIBLE	EDIBLE	EDIBLE	EDIBLE	EDIBLE
LOCATION		B1	B1	B4	B8	B8	B8	BIG TRACADIE RIVER
DATE		9/7/90	9/7/90	9/7/90	9/7/90	9/7/90	18/9/91	18/9/91
SIZE	No Limits	6.4 cm	8.9 cm	7.8 cm	7.9 cm	5.9 cm	*** 5.4 cm	*** 5.8 cm
ENVIROTEST LAB #	Available	D1159–25	D1159–21	D1159–24	D1159–19	D1159–23	D1316–1,3,4	D1316–2,5,6
RESULTS								
% LIPID		0.24	1.2	0.74	0.30	0.80	***0.36	***0.46
% MOISTURE		11.5 (84)	14.9 (82)	15.2 (84)	30.3 (82)	15.3 (84)	***84.0 (84)	***83.0 (84)
EOCl (Wet Weight Basis)		1.6 (0.29)	3.5 (0.74)	3.3 (0.62)	2.4 (0.62)	8.9 (1.68)	***1.39 (1.39)	***0.91 (0.91)

*** Average of three separate samples

TABLE XIX

March 9,1992

SPECIES	LIMITS	MUSSEL	OYSTER	STRIPED BASS	AM.EEL	ALGAE	ALGAE	ALGAE
PORTION		EDIBLE	EDIBLE	WHOLE	WHOLE			
LOCATION		B11	B12	B16	B16	B19	B19	B19
DATE		9/7/90	9/7/90	16/10/90	16/10/90	22/6/90	22/6/90	22/6/90
SIZE	No Limits	4.2 cm	6.6 cm	26 cm	67 cm			
ENVIROTEST LAB #	Available	D1159-22	D1159-18	D1159-12	D1159-15	D1159-17	D1159-17	D1159-17
RESULTS								
% LIPID		1.3	0.44	5.4	7.7			
% MOISTURE		23.7 (84)	11.1 (82)	30.6 (75)	32.9 (75)			
EOCl (Wet Weight Basis)		3.5 (0.73)	2.3 (0.46)	2.7 (0.97)	1.5 (0.56)	ND	ND	ND

*** Average of three separate samples

TABLE XIX

March 9,1992

SPECIES	LIMITS	GASPEREAU	STRIPED BASS	W.SUCKER
PORTION		WHOLE	WHOLE	WHOLE
LOCATION		B23	B23	B24
DATE		1/6/90	1/6/90	1/6/90
SIZE	No Limits	25 cm	35 cm	25 cm
ENVIROTEST LAB #	Available	D1159-14	D1159-11	D1159-16
RESULTS				
% LIPID		5.5	4.5	1.9
% MOISTURE		29.6 (75)	29.6 (75)	24.4 (75)
EOCl (Wet Weight Basis)		1.7 (0.60)	3.4 (1.20)	2.7 (0.89)

*** Average of three separate samples

Table XX. References used to determine acceptable pollutant levels in biota and sediment.

Reference #	Media	Contaminant	Reference
1	Biota	Mercury PCB Pesticides	Guide to Eating Ontario Sport Fish, 1991 Ontario Ministry of the Environment, 15th Ed. Limits for Edible Flesh, Unrestricted Consumption
2	Biota	Dioxin	Health & Welfare Canada (HWC) Limit of 20 pg/g is used here for relative comparison only. HWC now use a combination of concentration and local consumption patterns on a case by case basis to determine fishery closures.

Table XXI. Toxic limits of chemicals in sediments.

			mg/kg dry weight				
			Cu	Zn	Cd	Hg	Pb
EPA REGION V	nonpolluted	Giesy & Hoke 1990	25	90		1	40
	moderately polluted	"	50	200	6	1	60
Wisconsin	guideline	"	100	100	1	0.1	50
Ontario	no effect	"	15	65	0.6	0.1	23
	lowest effect	"	25	110	1	0.12	31
Beak Consultants guideline		"	85	143	2.5	0.6	55
Washington marine guideline		Annon 1991	390	410	5.1	0.41	450
Swain and Nijam 1991			310	260	5.8	0.41	300
Zarba 1989			136	760	31	0.8	132
O'Connor and Ehler 1991			390	960	6.7	0.41	530
Senten and Charlier 1991			35	480	2	0.5	530

		mg/kg organic carbon		
		PAH		PCB
Washington marine guideline	Annon 1991	Low MW	High MW	
		370	960	12

		µg/kg dry weight	
Long and Morgan 1990	ER-L*	4000	50
	ER-M*	32000	400
	AT*	22000	370

*ER-L, ER-M, AT = concentrations at which effects were observed in 10 and 50% cases, and almost always, respectively.

Table XXII. Heavy metals and toxic units in Miramichi sediments, sorted by in order of decreasing TU. The toxicants and thresholds are Cu = 390.00; Zn = 410.00; Cd = 5.10; Hg = 0.41; Pb = 450.00

#	Station	Concentrations (µg/g) Cu	Zn	Cd	Hg	Pb	Quick	Tox.U.	Symb.
78	S8-UPPER	53.4	272.5	0.88	0.43	57.6	01010	2.15	X
92	S7-LOWER	92.4	176.5	0.44	0.21	382.9	00011	2.12	X
85	S7-MIDDLE	40.0	357.8	0.98	0.27	70.4	01010	2.01	X
76	S6-UPPER	34.6	372.5	1.15	0.21	72.8	01010	1.90	X
84	S6-MIDDLE	55.0	379.8	0.16	0.23	57.3	01010	1.79	X
77	S7-UPPER	32.9	271.1	0.77	0.30	57.7	01010	1.76	X
54		42.2	350.0	1.31	0.15	38.2	01000	1.72	X
50		29.0	146.0	0.65	0.12	223.0	00000	1.35	X
74	S4-UPPER	24.3	166.3	0.23	0.30	36.8	00010	1.33	X
93	S8-LOWER	15.4	91.1	0.39	0.35	29.7	00010	1.26	X
49	below CH.	27.5	246.0	0.99	0.12	44.0	01000	1.25	x
63		16.9	142.0	0.61	0.19	30.0	00000	1.05	x
73	S3-UPPER	22.3	125.7	0.13	0.24	30.0	00010	1.04	x
23		25.0	206.0	1.10	0.07	39.0	01000	1.04	x
71	S1-UPPER	12.6	97.6	0.19	0.27	23.9	00010	1.02	x
66		23.2	198.0	0.79	0.08	38.6	00000	0.99	x
62		23.7	194.0	0.78	0.09	37.5	00000	0.98	x
20		21.0	158.0	0.93	0.10	33.0	00000	0.94	x
51		20.0	127.0	0.48	0.11	84.0	00000	0.92	x
55		18.9	158.0	0.66	0.11	33.4	00000	0.91	x
72	S2-UPPER	19.8	107.3	0.14	0.21	28.0	00010	0.91	x
75	S5-UPPER	18.1	124.5	0.25	0.18	26.4	00000	0.90	x
27		18.0	154.0	0.80	0.10	27.0	00000	0.88	.
46		19.1	181.0	0.71	0.07	36.4	00000	0.88	x
1	off Sheld	21.1	177.0	0.84	0.04	49.3	00000	0.85	x
81	S3-MIDDLE	16.8	83.8	0.14	0.20	24.3	00000	0.82	x
86	S8-MIDDLEnw	14.4	82.3	0.21	0.19	24.3	00000	0.80	x
68		18.5	161.0	0.65	0.06	34.4	00000	0.79	x
80	X2-MIDDLE	17.8	69.1	0.17	0.20	21.1	00000	0.78	x
24		20.0	117.0	0.56	0.10	21.0	00000	0.74	.
82	S4-MIDDLE	19.8	91.6	0.17	0.15	26.3	00000	0.73	.
35		14.0	118.0	0.65	0.09	21.0	00000	0.72	.
41		15.0	150.0	0.47	0.06	34.9	00000	0.71	.
64		18.2	146.0	0.63	0.04	29.4	00000	0.70	.
40		14.9	179.0	0.38	0.03	40.1	00000	0.70	.
38	Sheldr I	17.0	131.0	0.64	0.06	25.0	00000	0.69	.
5		20.8	146.0	0.51	0.05	27.3	00000	0.69	.
9		17.7	131.0	0.55	0.05	35.1	00000	0.68	.
88	S3-LOWER	18.2	78.4	0.13	0.15	20.6	00000	0.68	.
2	S3-LOWER	16.8	147.0	0.66	0.03	29.1	00000	0.67	.
26		15.0	101.0	0.48	0.10	22.0	00000	0.67	.

continued..

Table XXII

#	Station	Concentrations (μg/g) Cu	Zn	Cd	Hg	Pb	Quick	Tox.U.	Symb.
37		17.0	124.0	0.61	0.06	26.0	00000	0.67	.
52		13.0	138.0	0.62	0.05	23.4	00000	0.67	.
12		20.1	146.0	0.41	0.04	31.8	00000	0.66	.
31		17.0	140.0	0.62	0.04	25.0	00000	0.66	.
6		19.1	146.0	0.60	0.03	33.1	00000	0.66	.
10	Grand DunI	19.3	137.0	0.51	0.04	31.8	00000	0.64	.
87	S2-LOWER	18.2	80.1	0.13	0.13	21.8	00000	0.63	.
S19	Newcastle	14.0	108.0	0.51	0.07	17.0	00000	0.61	.
14		19.4	124.0	0.35	0.04	34.2	00000	0.60	.
57	Loggieville	12.2	118.0	0.48	0.05	28.7	00000	0.59	.
039	Newcastle	19.6	130.0	0.34	0.04	24.0	00000	0.59	.
25	Midw Ch/L	13.0	91.0	0.46	0.08	21.0	00000	0.59	.
15	Dumps 6B	16.6	117.0	0.47	0.04	28.5	00000	0.59	.
4	Oak Pt	16.2	116.0	0.52	0.04	29.8	00000	0.59	.
79	S9-UPPER	2.5	41.1	0.17	0.17	11.8	00000	0.58	.
42		15.3	112.0	0.04	0.05	23.4	00000	0.58	.
65		14.1	121.0	0.47	0.04	22.5	00000	0.58	.
61		13.0	118.0	0.44	0.04	26.4	00000	0.57	.
60		13.2	120.0	0.45	0.04	25.0	00000	0.57	.
89	S4-LOWER	11.0	46.6	0.11	0.15	17.1	00000	0.57	.
58		14.1	114.0	0.43	0.05	23.7	00000	0.57	.
91	S6-LOWER	18.6	80.6	0.15	0.09	29.9	00000	0.56	.
13		21.2	118.0	0.26	0.04	29.1	00000	0.55	.
69		12.7	105.0	0.39	0.04	26.9	00000	0.53	.
11		17.1	102.0	0.31	0.04	30.6	00000	0.52	.
70		12.0	102.0	0.35	0.04	27.7	00000	0.51	.
83	S5-MIDDLE	11.2	69.6	0.16	0.08	17.6	00000	0.46	.
22		8.0	58.0	0.31	0.09	7.0	00000	0.46	.
7		14.8	102.0	0.34	0.03	19.7	00000	0.46	.
30		10.0	81.0	0.28	0.06	12.0	00000	0.45	.
8	Grab sam	9.7	118.0	0.38	0.02	10.5	00000	0.45	.
16	7B	14.7	93.8	0.35	0.03	19.0	00000	0.45	.
90	S5-LOWER	9.1	69.2	0.15	0.08	14.4	00000	0.45	.
17	10B	16.8	99.4	0.26	0.03	17.5	00000	0.44	.
36		11.0	70.0	0.25	0.05	13.0	00000	0.40	.
28		7.0	56.0	0.20	0.07	12.0	00000	0.39	.
59		9.4	89.9	0.30	0.02	20.6	00000	0.39	.
32		8.0	68.0	0.25	0.05	10.0	00000	0.38	.
33		10.0	67.0	0.23	0.04	17.0	00000	0.37	.
18	13A	14.6	79.4	0.26	0.02	12.4	00000	0.37	.
56		9.1	84.3	0.24	0.02	19.5	00000	0.36	.
3		9.3	74.6	0.26	0.02	18.0	00000	0.35	.
67	Sheldr I	9.3	73.2	0.19	0.02	12.7	00000	0.32	.
21	Douglastw	6.0	46.0	0.26	0.05	6.0	00000	0.31	.
43		6.9	71.5	0.23	0.02	12.5	00000	0.30	.

continued...

Table XXII

#	Station	Concentrations (μg/g) Cu	Zn	Cd	Hg	Pb	Quick	Tox.U.	Symb.
21	Douglastw	6.0	46.0	0.26	0.05	6.0	00000	0.31	.
43		6.9	71.5	0.25	0.02	12.5	00000	0.30	.
34		8.0	65.0	0.24	0.02	9.0	00000	0.29	.
47		7.0	72.1	0.21	0.01	11.2	00000	0.28	.
53		8.1	61.7	0.14	0.02	20.5	00000	0.28	.
29		7.0	42.0	0.15	0.03	7.0	00000	0.26	.
48		7.1	66.4	0.18	0.01	11.6	00000	0.24	.
45		6.9	60.9	0.16	0.01	10.1	00000	0.23	.
44	Douglastw	6.4	58.9	0.18	0.01	10.1	00000	0.23	.

It can be seen that the samples 50, 51, and 92 are "outliers" because of an abnormally high Pb concentration. Also, most of the samples numbered 71 and higher, analyzed by one laboratory, may include a laboratory bias.

TABLE XXIII. Organic carbon, PAH and PCB in Miramichi sediments.

	C g/kg	PCB µg/kg	PCB µg/gC	PAH µg/Kg	PAH µg/gC
	56.0	95	1.7		
	32.5	78	2.4		
	6.1	5	0.8		
	23.7	36	1.5		
	39.6	57	1.4		
Miramichi Bay	51.5	29	0.6		
	23.3	20	0.9		
	7.0	5	0.7		
	31.6	52	1.6		
	41.0	50	1.2		
	35.6	54	1.5		
	21.7	34	1.6		
	38.2	37	1.0		
	34.0	34	1.0		
	23.5	17	0.7		
	13.9	14	1.0		
	13.1	5	0.4		
Newcastle	1.77	13	7.3		
	4.79	16	3.3		
Douglastown	1.08	5	4.6		
	1.42	5	3.5		
	4.24	5	1.2		
	3.11	5	1.6		
Midway Chatham/Low	1.28	5	3.9		
	2.44	39	16.0		
	2.64	15	5.7		
	1.54	5	3.2		
	1.36	5	3.7		
	1.82	5	2.7		
	2.93	18	6.1		
	1.6	5	3.1		
	2.43	5	2.1		
	1.09	5	4.6		
	6.22	24	3.9		
	2.14	5	2.3		
Sheldrake Island	3.04	22	7.2		
	2.82	11	3.09		
Newcastle	21.0	21	1.0	1110	53
	21.0	21	1.0	1110	53
	26.1	42	1.6	1185	45
	16.8	11	0.7	515	31
	18.2	5	0.3	355	20

continued...

Table XXIII

	C g/kg	PCB µg/kg	PCB µg/gC	PAH µg/Kg	PAH µg/gC
Douglastown	18.2	5	0.3	355	20
	31.7	107	3.4	2370	75
	18.2	5	0.3	405	22
	20.5	5	0.2	395	19
	46.9	400	8.5	1740	37
below Chatham	35.8	5	0.1	5190	145
	35.8	5	0.1	5190	145
	29.2	70	2.4	1940	66
	14.2	47	3.3	460	32
	40.5	390	9.6	1195	30
	33.7	15	0.4	1170	35
	20.3	60	3.0	455	22
	26.7	10	0.4	655	25
Loggieville	31.0	5	0.2	535	17
	19.2	26	1.4	1950	102
	26.2	62	2.4	755	29
	26.2	40	1.5	825	31
	55.1	21	0.4	705	13
	31.9	55	1.7	675	21
	35.8	72	2.0	685	19
	28.9	78	2.7	1310	45
	47.0	83	1.8	880	19
Sheldrake Island	27.9	5	0.2	385	14
	38.4	17	0.4	630	16
	31.4	31	1.0	1310	42
	31.4	33	1.1	1270	40
S1				152	
S2				141	
S3				329	
S4				655	
S5				1393	
S6				671	
S7				2258	
S8				61489	
S9				1265	
Avg		38	2.4	2626	42
Std		66	2.6	9368	33
Max		400	16.0	61489	145
Min		5	0.1	141	13
Median		21	1.6	825	31

Table XXIV

SAMPLING POINT INDEX - SEDIMENT AND BIOTA

MREAC SAMPLING POINTS FOR BIOTA

B1 - North End of Portage Island

B2 - West Side of Portage Island

B3 - Midway between Fox and Portage Islands

B4 - East Side Bay du Vin Island

B5 - Midway between Bay du Vin Island and Egg Island

B6 - West Side of Egg Island

B7 - Bay du Vin (Original DFO dioxin station)

B8 - Mouth of Black River

B9 - Black River Estuary

B10 - Mouth of White's Brook

B10a - Midway between White's Brook and Dredged Channel

B10b - Midway between White's Brook and Cheval Point

B11 - Northeast of Sheldrake Island

B12 - East Side of Sheldrake Island

B13 - West Side of Sheldrake Island

B14 - Nappan Bay

B15 - Upstream of Big Brook (N Side)

B16 - Millbank Trap

B17 - MRDC Salmon Holding Pens

B18 - Centennial Bridge (NW end)

B19 - Morrisey Bridge (East End)

B20 - Strawberry Marsh Inlet

B21 - Vye's Beach

B22 - NW Miramichi mid-channel opposite MPPI effluent

Table XXIV

B23 - NW Miramichi South Side opposite MPPI mill (350 yd below old bridge crossing)

B24 - NW Miramichi South Side opposite MPPI mill

B25 - NW Miramichi Bridge (North Side)

B26 - NW Miramichi at Sunny Corner

B27 - NW Miramichi 3/4 mile above Hatchery Brook

B28 - NW Miramichi at Strathdam (1/4 mile above Brander's Turn)

B29 - Little SW Miramichi at Red Bank

MREAC SAMPLING POINTS FOR SEDIMENT

S1 - Centre of Dumpsite B
(2.5 nautical miles from Point aux Carr)
(1.85 nautical miles from Grand Dune Island)
(3.45 nautical Miles from Bay du Vin Island)

S2 - East of Dumpsite B
(4.2 nautical miles from Point aux Carr)
(3.0 nautical miles from Bay du Vin Island - west end)
(3.45 nautical miles from Grand Dune Island)

S3 - North of Dumpsite B
(1.5 nautical miles from Grand Dune Island)
(3.8 nautical miles from Point aux Carr)
(4.45 nautical miles from Bay du Vin Island)

S4 - South of Dumpsite B
(1.0 nautical miles from Point aux Carr)
(2.4 nautical miles from Bay du Vin Island)
(2.5 nautical miles from Bay du Vin Beach)

S5 - Southwest of Dumpsite B
(1.0 nautical miles from Oak Point)
(2.0 nautical miles from Cheval Point)
(2.2 nautical miles from Point aux Carr)

S6 - Centennial Bridge (Between the 5th and 6th piers counting north from the north edge of the dredge channel)

S7 - Morrisey Bridge (100 metres south of West bank abutment and 30 metres upstream)

S8 - Northwest Miramichi (150 metres downstream of highway #8 bridge and 80 metres out from south bank)

S9 - Southwest Miramichi (100 metres downstream of rail bridge near mouth and 60 metres in from southeast bank)

Table XXIV

S11 - Southwest Miramichi	(Under power line near mouth - first of four equally spaced points across river in a N-S direction)
S12 - Southwest Miramichi	(Under power line near mouth - second of four equally spaced points across river in a N-S direction)
S13 - Northwest Miramichi	(Under power line near mouth - first of four equally spaced points across river in a N-S direction)
S14 - Northwest Miramichi	(Under power line near mouth - second of four equally spaced points across river in a N-S direction)
S15 - Northwest Miramichi	(Under power line near mouth - third of four equally spaced points across river in a N-S direction)